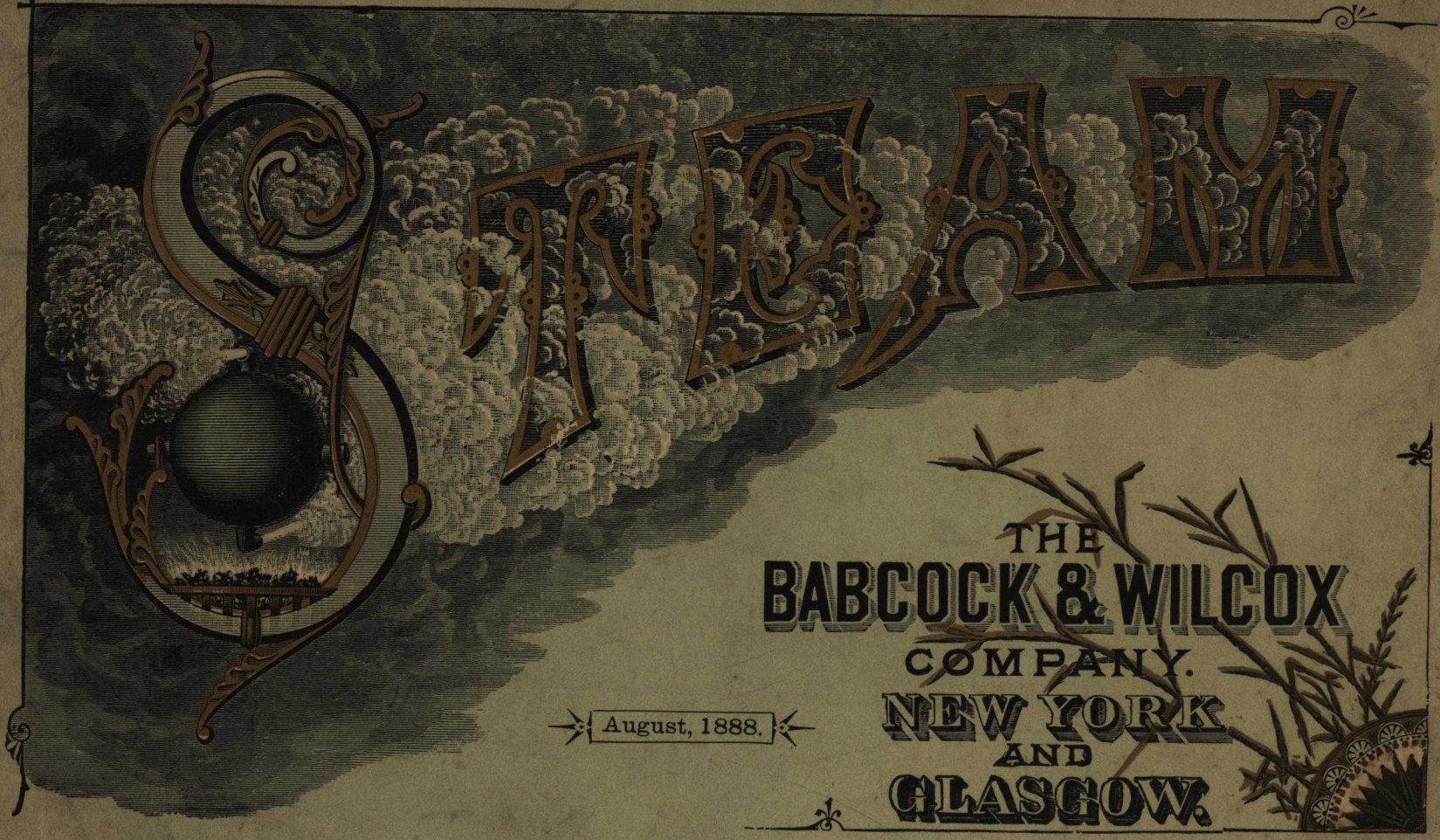
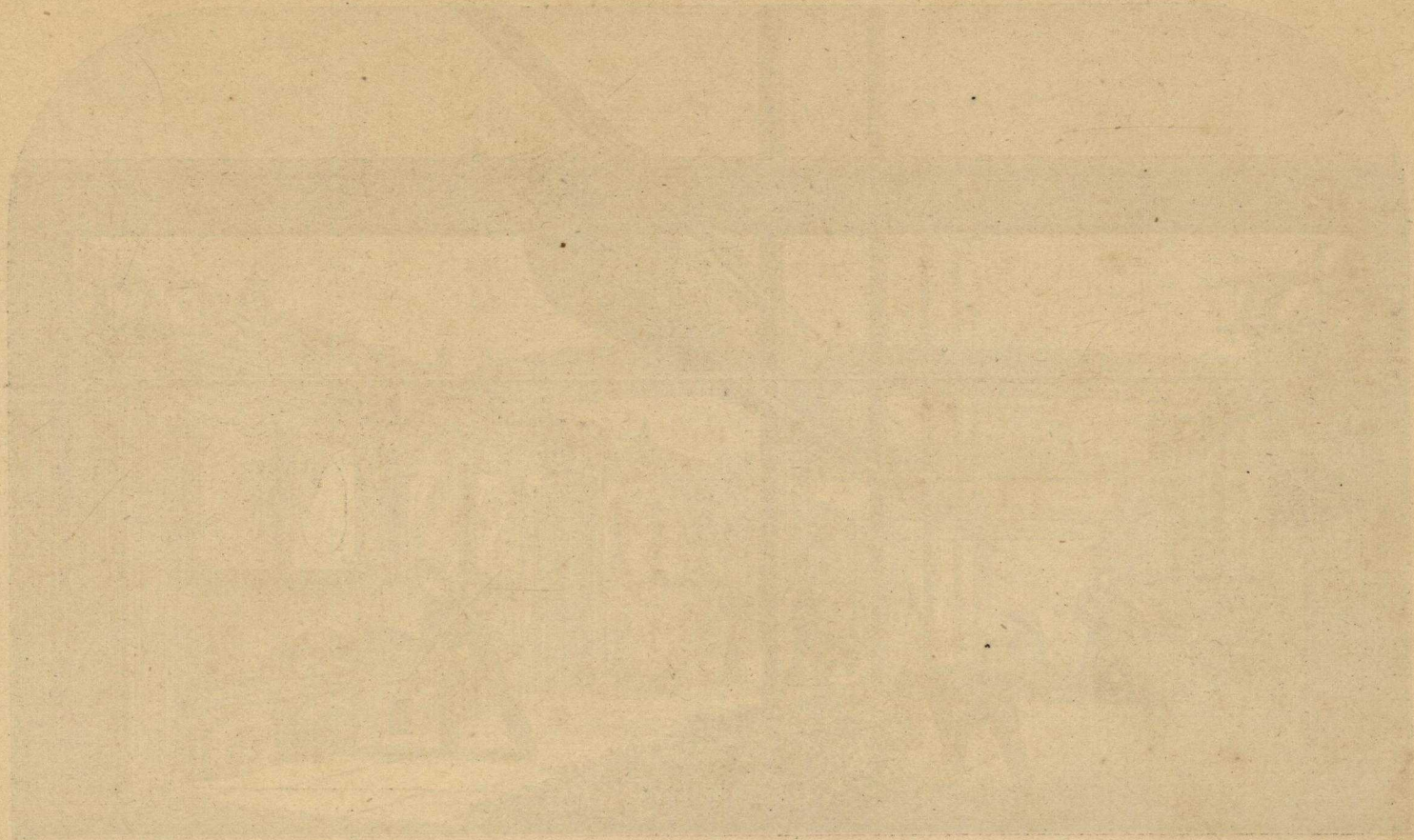
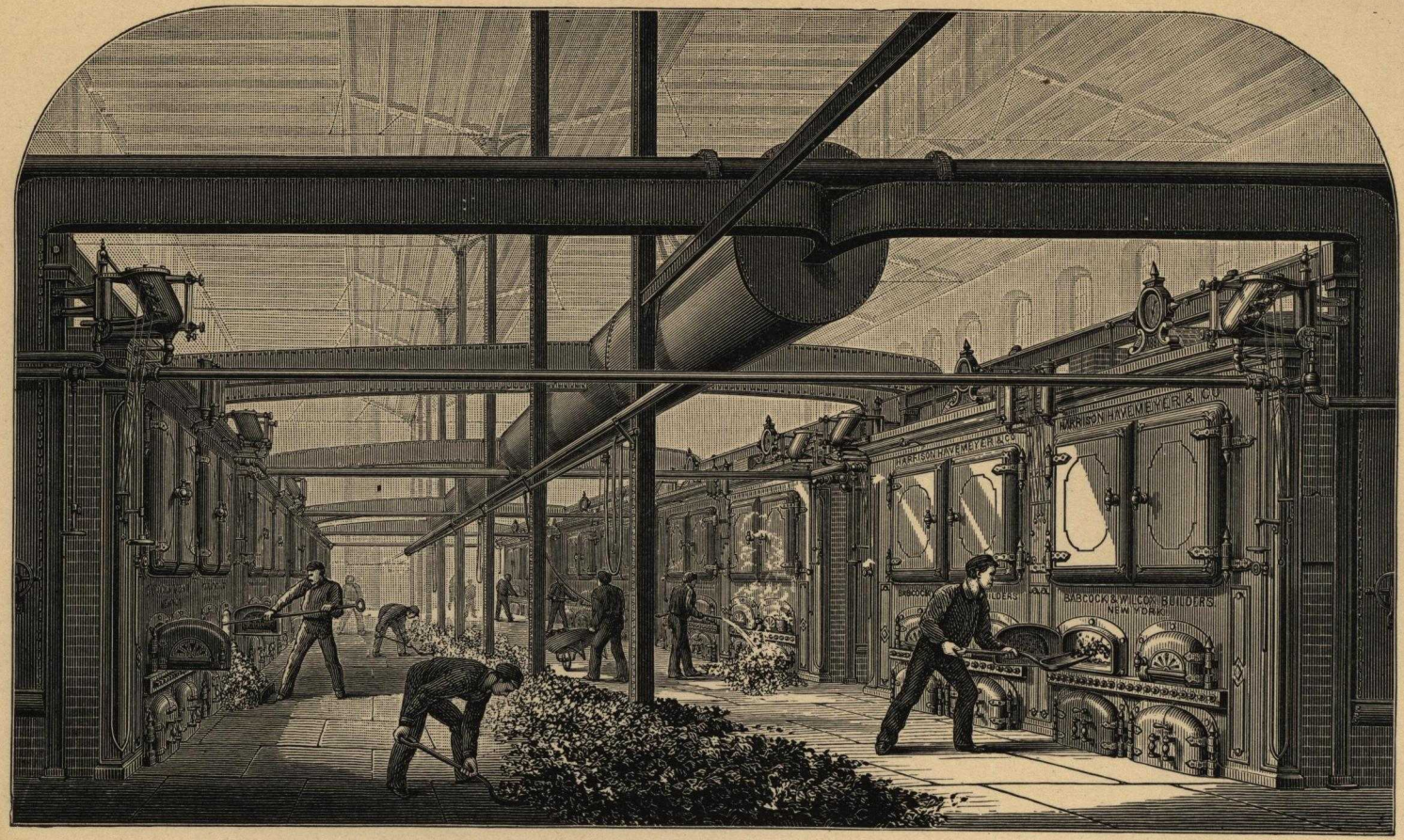
BOSTON OFFICE: NO. 8 OLIVER STREET.







PERSPECTIVE VIEW OF THE FIRE ROOM OF HARRISON, FRAZER & CO., PHILADELPHIA, PA., 6,218 H. P. BABCOCK & WILCOX BOILERS.

STEAM
ITS GENERATION AND USE
WITH
CATALOGUE OF THE MANUFACTURES
OF THE
BABCOCK AND WILCOX COMPANY
30 Cortland Street NEW YORK.
107 Hope Street GLASGOW.
Nineteenth Edition, 1888.

PREFACE.

(*To First Edition, 1879.*)

WHILE making known the character and quality of our manufactures, we have endeavored at the same time to present to our friends and customers a variety of useful information, not readily accessible to them in other ways. The facts and figures herein given are derived largely from practical experience, and can be depended upon as correct. Very few of them were ever published before, while those derived from the researches of others have been simplified and adapted to the wants of manufacturers. It is with the intention, at some future time, to collect them, with others, into a more permanent form, that they have been copyrighted.

(*To Eleventh Edition, 1883.*)

In preparing a new edition of "STEAM," we have revised the whole, and added much new and valuable matter, which we trust our customers will find useful and interesting.

(*To Thirteenth Edition, 1885.*)

Having again revised "STEAM," and enlarged it by the addition of new and useful information, not published heretofore, we shall feel repaid for the labor, if it shall prove of value to our customers.

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Press of the "American Art Printer," 22 College Place, New York City.

USEFUL INFORMATION
FOR
MANUFACTURERS AND STEAM USERS.

ECONOMY IN THE USE OF COAL is a matter of great and growing importance. It is estimated that the annual production of coal in the world at the present time is not far from 300,000,000 tons. The report of the Royal Commission in England in 1870, shows the distribution as follows:—

Metallurgy and Mines,	44 per cent.
Domestic purposes, including gas and water,	26 " "
General Manufacturing,	25 " "
Locomotion by sea and land,	5 " "

As a considerable part of the coal used in metallurgy and mines, as also that for domestic water supply, is used for power, we shall not be far wrong in estimating that one-half of all the coal mined, or 150,000,000 tons annually, is used for making steam. A low estimate of the value of this coal at the place of use would be an average of $2.50 per ton, which gives as the present annual expenditure for steam, the sum of $375,000,000; from which it will be seen how largely even a small per cent. of saving would add to the wealth of the world.

While manufacturers and engineers have given much care to the improvement of the steam engine, whereby they might reduce the consumption of steam for a given amount of power, but little attention, comparatively, has been given to securing economy in its generation. In fact, the boilers in use at the present day, are substantially the same as were in common use at the close of the last century, and but slight advance has been made in their economy. Of late years, however, steam users have begun to realize that there are principles and aims of equal prominence, and greater importance to be considered in choosing a boiler, to the selection of a steam engine.

Engineering experience and scientific investigation have established the following as the

REQUIREMENTS OF A PERFECT STEAM BOILER.

1st. It should be **simple in construction** and be made of the **best materials** sanctioned by use.

2d. It should have a constant and thorough **circulation of water** throughout the boiler, so as to maintain all parts at one temperature.

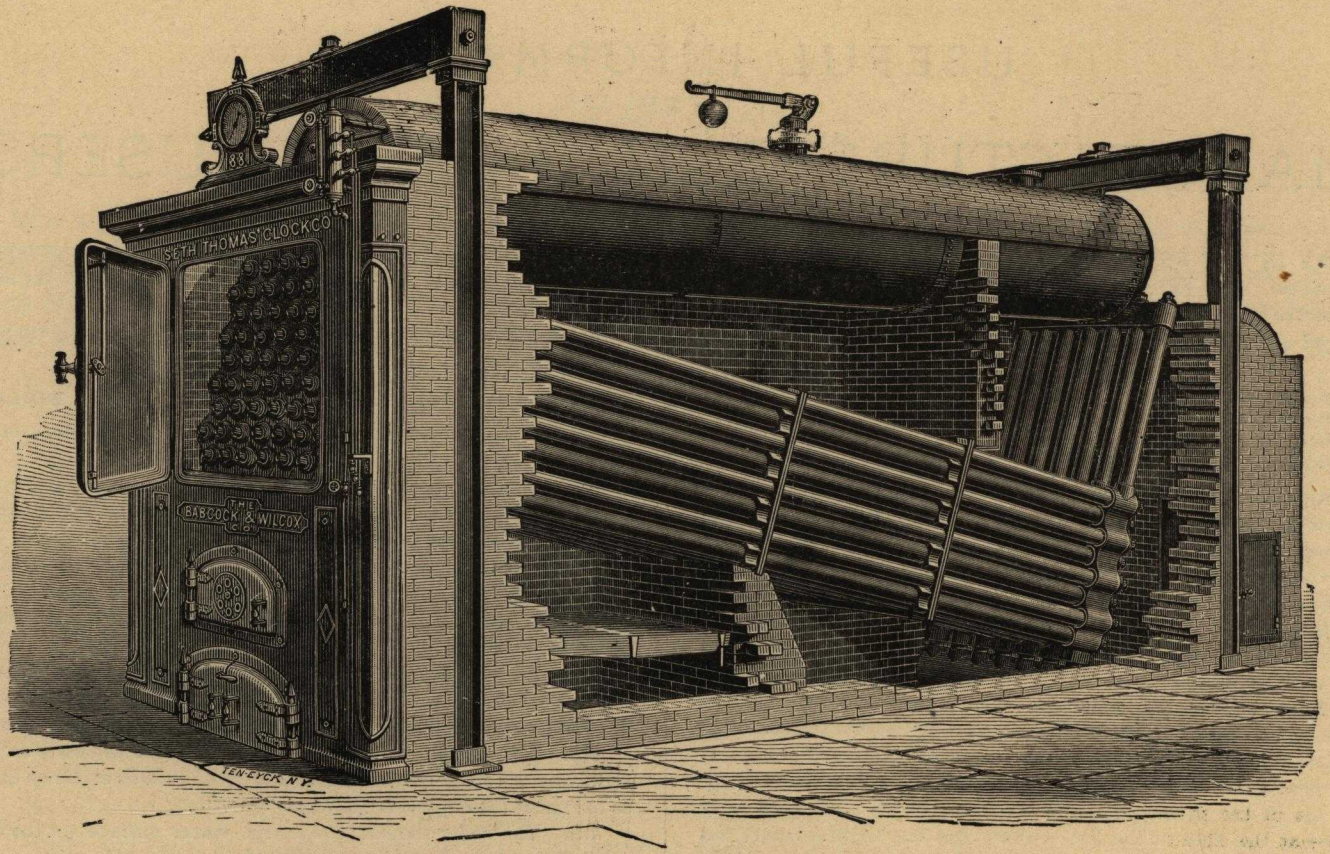
3d. It should be provided with a **mud-drum** to receive all impurities deposited from the water in a place removed from the action of the fire.

4th. It should be provided with a **combustion chamber,** so arranged that the combustion of the gases commenced in the furnace may be completed before the escape to the chimney.

5th. All parts should be **readily accessible for cleaning and repairs.** This is a point of the greatest importance as regards safety and economy, and has heretofore been possessed only by plain cylinder and large flue boilers.

6th. The **heating surface** should be arranged as nearly as possible at right angles to the currents of heated gases, and so break up the currents as to extract the entire available heat therefrom.

7th. The boiler should have a large **water surface** for the disengagement of the steam from the water in order to prevent foaming.



125 H. P. Babcock & Wilcox Boilers, at the Seth Thomas Clock Co's, Thomaston, Conn. Erected 1880.

8th. It should have **large and free passages** between the different sections to equalize the water line and pressure in all.

9th. It should have a **steam and water capacity** sufficient to prevent sudden fluctuation in pressure or water level.

10th. It should have, if possible, **no joints exposed** to the direct action of the fire.

11th. It should have a **great excess of strength** over any legitimate strain, and should be so constructed as **not to be liable to be strained by unequal expansion.**

12th. It should be **durable** in construction, and not liable to require early repairs.

13th. The **water space should be divided into sections,** so arranged that should any section give out, no general explosion can occur, and the destructive effects be confined to the simple escape of the contents.

14th. It should be **proportioned for the work** to be done, and be capable of working to its full rated capacity with the highest economy.

15th. It should be provided with the **very best gauges, safety valves,** and other fixtures.

IMPORTANCE OF PROVIDING AGAINST EXPLOSION.

That the ordinary forms of boilers are liable to explode with disastrous effect, is conceded. That they do so explode is witnessed by the sad list of casualties from this cause every year, and almost every day. In the year 1880, there were 170 explosions reported in the United States, with a loss of 259 lives, and 555 persons injured.

The **Hartford Steam Boiler Inspection and Insurance Company** report that up to January 1, 1885, they had made in all, **560,979** inspections, and had discovered 303,718 defects, *of which* **64,216** *were considered dangerous.* If now the above were a fair average of the boilers in ordinary use —and who shall say they are not?—we have the startling fact that about **one boiler in nine,** in common use, **is in a "dangerous condition."** That more do not explode, is probably due less to intelligent watchcare than to the fortunate lack of all the necessary conditions existing at one time

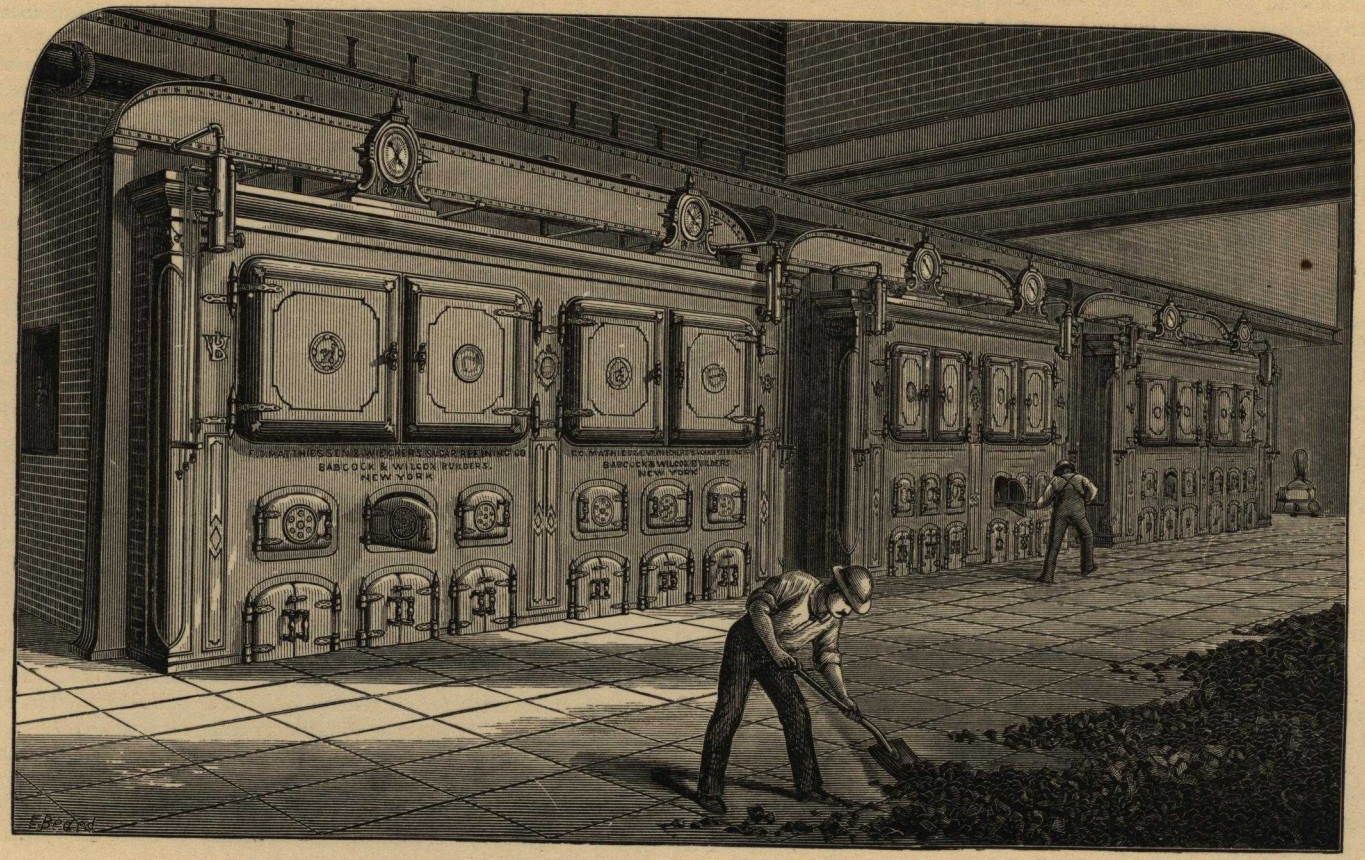
CAUSES OF EXPLOSION.

It is now fully established by the experience of Boiler Insurance Associations in this country and England, that all the mystery of boiler explosions consists in a **want of sufficient strength** to withstand the pressure. This lack of strength may be inherent in the original construction, but is most frequently the effect of **weakening of the iron** by strains due to unequal expansion caused by unequal heating of different portions of the boiler; or it may be due to corrosion from long use or improper setting.

If steam boilers are properly proportioned and constructed, they will, when new, be safe against considerably more pressure than the safety valve is set to; and the hydrostatic test, properly applied, may discover faults in material, or the weakening effects of corrosion; but, against the danger resulting from **unequal expansion,** ordinary boilers have no protection; a fact not properly appreciated by either engineers or the public.

In getting up steam many boilers will be very hot in some parts, while other parts will be actually cold; of course, under these conditions, enormous strains must occur in some portions of the boiler, which are thereby weakened; and these strains being repeated every time steam is raised, if at no other time, will eventually so far destroy the strength of the line or point of greatest strain that rupture must result; generally the rupture is small and gradual, but sometimes large and productive of disastrous explosions. In the boilers examined by the Hartford Boiler Insurance Company, up to 1880, **11,757 fractures** in plates were found in, at, or near the seams or through the line of rivets, **5,079** of which, or about one-half, had arrived at a dangerous state before discovery.

Want of circulation of the water in boilers is a frequent and prolific cause of unequal expansion, and deteriorating strains, and little, if any, provision is made for circulation in all ordinary construction of boilers. Another source of danger in all ordinary boilers is **low water;** and constant vigilance is required to keep the water at a proper height. In many boilers the fall of only a few inches in the water-line will cause the crown-sheet or some other portion to be exposed to the direct action of the fire, whence it becomes quickly over-heated, and weakened to such an extent that an explosion is likely to occur.



1500 H. P. Babcock & Wilcox Boilers, at F. O. Matthiessen & Wiecher's Sugar Refining Co., Jersey City, N. J. 2d Order. Erected 1877.

Another frequent cause of unequal expansions, and also of weakening by burning and blistering the iron, is the presence of **deposit or scale** on the heating surface. This is liable to occur in any boiler, but in very many there is no adequate provision for removing it when formed. This is particularly the case with "tubular" and "locomotive" boilers.

There is good reason for believing that most of the **mysterious explosions** of boilers which stand the Inspector's test, and then explode at a much less pressure, are due to the **weakening effects of unequal expansions**; for a boiler that will stand a hundred pounds test this week cannot explode the next week at fifty pounds pressure, unless it has suddenly become wonderfully reduced in strength, and no corrosion or other natural cause, with which we are acquainted, save expansion, can produce this result. When we consider that strains from difference of expansion are generally greatest when firing up, and when there is no pressure in the boiler, we can see that the time may arrive when a crack is started or the parts weakened, so as to give way under a moderate pressure just after the test has been made; and this is the probable reason why so many boilers explode in getting up steam, or so soon after, or upon pumping in cold water, or, even, as in a recent case in England, while cooling off.

HOW TO PROVIDE AGAINST EXPLOSIONS.

Very much thought and experiment has been expended on this problem, but though many forms of boilers have been produced, which have attained practical safety from explosion, yet in nearly all of them there have been ignored certain elements necessary at the same time to make them valuable as generators of steam for practical work. Hence, the very name of "safety boiler" has unfortunately become, to some persons, *prima facie* evidence of undesirability. But safety is not incompatible with any of the other essentials of a perfect steam generator, and may be secured without detracting from any other desirable feature.

The first element of safety is **ample strength.** This can be best attained in connection with thin heating surface, by small diameters of parts; but this must not be carried so far as to antagonize the equally important features of large capacity and disengaging surface.

The second and most important element of safety, is such a structure that the original **strength can not be destroyed** by deteriorating strains, from expansion or otherwise. This can be attained in two ways—by rendering unequal expansion impossible, or by providing such elasticity that, should it occur, it can produce no deteriorating strain.

The third element of safety is such an arrangement of parts that when, through gross carelessness or design, the water becomes low and the boiler overheated, a rupture, if it occur, can produce no serious disaster.

WATER-TUBES AN ELEMENT OF SAFETY.

[From the *Manufacturer and Builder*, Feb., 1880.]

Some recent actual occurrences have a very suggestive bearing upon the relative degree of immunity from violent and disastrous explosions possessed by the water-tube and fire-tube systems of boiler construction respectively.

The first case, is that of an accident resulting through gross carelessness to a steam boiler on the water-tube system as constructed by Messrs. Babcock & Wilcox. The circumstances of the case were such as to make the test to which the boiler was put a most severe one, and the fact that the result was *not* a disastrous explosion, scores several points in favor of the water-tube system.

The boiler here referred to is located in the Brooklyn Sugar Refinery, and is rated at 300 horse-power, being one of a set of 1500 H. P. Recently, by one of those oversights that now and then cost scores of lives under the same circumstances, the feed-water was cut off, and not noticed until the water

FIG. 1.

level became so low that the boiler was nearly empty and the tubes were overheated. The result is shown in Fig. 1. One of the tubes burst, and this was the extent of the damage, which was speedily repaired at a cost of $15, and the works were running the next day.

The second case is very analagous, but is even more instructive, as the boiler was subjected to a severer ordeal than the other. This boiler is in the

Babcock & Wilcox Boilers at New Orleans Exposition, 1885. Total, 1500 H. P.

Elizabeth (N. J.) jail, and was of the same kind as that in the foregoing case. It was in charge of one of the convicts, who, after starting his fire as usual in the morning, was surprised not to observe, after an hour or so of waiting, any signs of activity in his steam gauge. This fact was disclosed to some of the officials of the prison, and an investigation was instituted to ascertain the cause, disclosing a fact that at once relieved the boiler from any responsibility for the absence of steam—for there was no water in it. It also showed that the blow-cock was wide open, and had been since the night before. What followed, we give in Mr. Watson's own words:

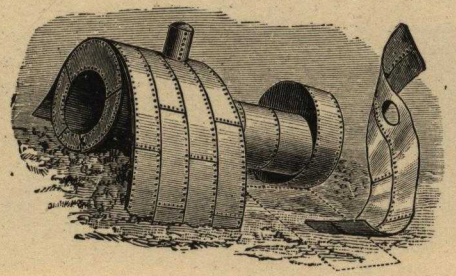
"After the syndicate had opened the furnace door and seen the white hot tubes, it was thought a good idea to get some water in the boiler as quickly as possible; so they shut the blow-cock (for a wonder) and turned on the city water. The result justified their expectations; steam was made very quickly; for a moment it roared through the safety valve with a fearsome sound—and that is all that happened, beyond the renewal of a few of the tubes, and one steel casting."

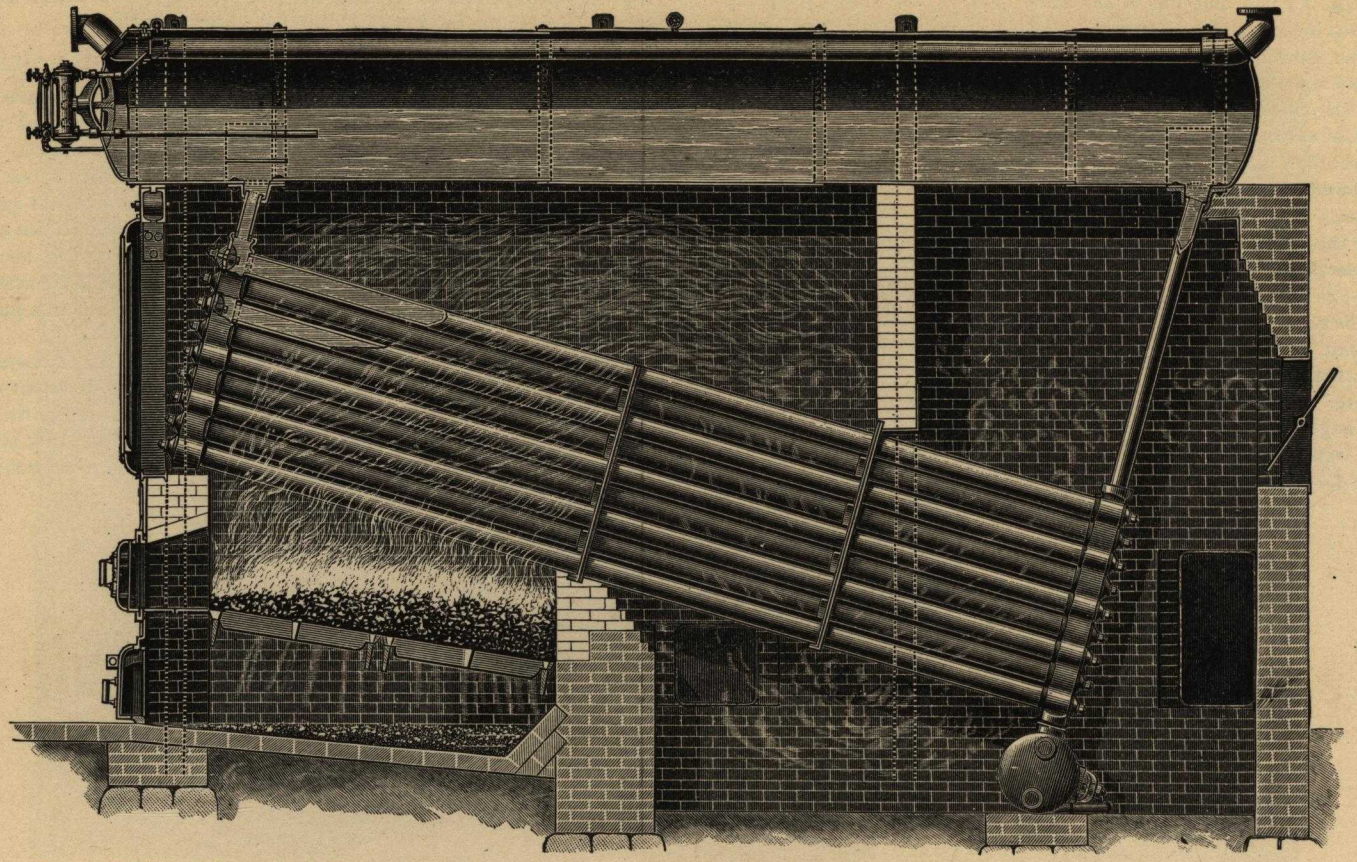
What might have happened had either of these boilers been fire-tube instead of water-tube boilers, we do not pretend to say, but think Mr. Watson is not far out of the way in venturing the statement that "it is not contrary to precedent to say that, in all probability, there would have been an opportunity for a coronor's inquest and a new jail."

THE BABCOCK & WILCOX WATER-TUBE BOILER

has all the elements of safety, in connection with its other characteristics of economy, durability, accessibility, etc. Being composed of wrought iron tubes, and a drum of comparatively small diameter, it has a **great excess of strength** over any pressure which it is desirable to use. As the rapid circulation of the water insures **equal temperature in all parts,** the strains due to **unequal expansion cannot occur** to deteriorate its strength. The construction of the boiler, moreover, is such, that should unequal expansion occur under extraordinary circumstances, no objectionable strain can be caused thereby, ample elasticity being provided for that purpose in the method of construction.

In this boiler, so powerful is the circulation that as long as there is sufficient water to about half fill the tubes, a rapid current flows through the whole boiler; but if the tubes should finally get almost empty, the circulation then ceases and the boiler might burn and give out; by that time, however, it is so nearly empty as to be incapable of harm if ruptured.





Babcock & Wilcox Boiler, 416 H. P., at Pittsburgh Steel Casting Co., Pittsburgh, Pa. Erected 1883. Showing Wrought Iron Front, and Flanged Drum-heads.

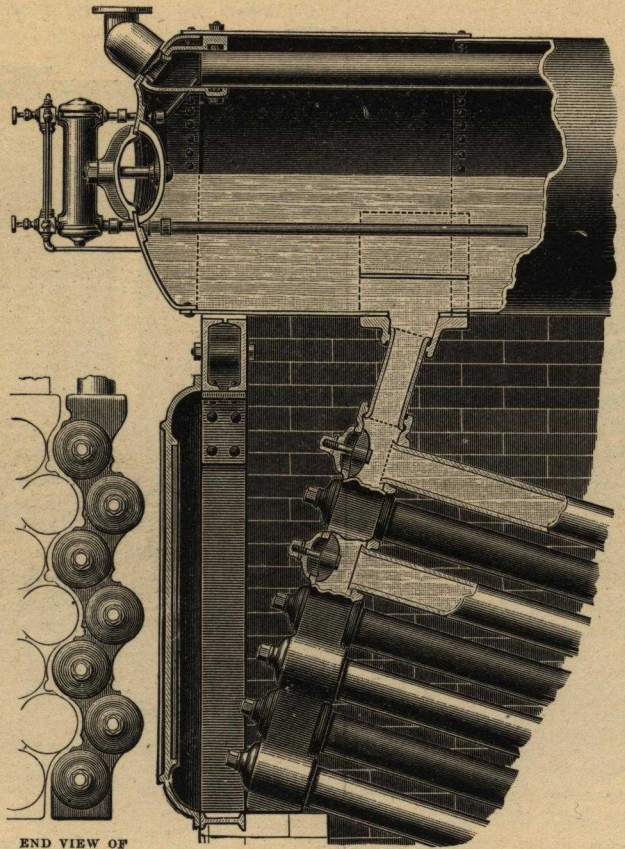
DESCRIPTION OF THE BABCOCK & WILCOX

WATER-TUBE BOILER.

CONSTRUCTION.

THIS boiler is composed of **lap-welded wrought iron tubes,** placed in an inclined position and connected with each other, and with a horizontal **steam and water drum,** by vertical passages at each end, while a **mud-drum** connects the tubes at the rear, and lowest point in the boiler.

The **end connections** are in one piece for each vertical row of tubes, and are of such form that the tubes are "staggered" (or so placed that each horizontal row comes over the spaces in the previous row). The holes are accurately sized, made tapering, and the tubes **fixed therein by an expander.** The sections thus formed are connected with the drum, and with the mud-drum also, by short **tubes expanded into bored holes,** doing away with all bolts, and leaving a clear passage-way between the several parts. The openings for cleaning opposite the end of each tube are closed by hand-hole plates, the joints of which are made in the most thorough manner by milling the surfaces to accurate metallic contact, and are held in place by **wrought iron forged clamps** and bolts. They are tested and made tight under a hydrostatic pressure of 300 pounds per square inch, *iron to iron, and without rubber packing, or other perishable substances.*



END VIEW OF HEADER.

PARTIAL VERTICAL SECTION.

The **steam and water drums** are made of flange iron or steel, of extra thickness, and double riveted. They can be made for any desired working pressure, but are always tested at 150 pounds per square inch unless otherwise ordered.

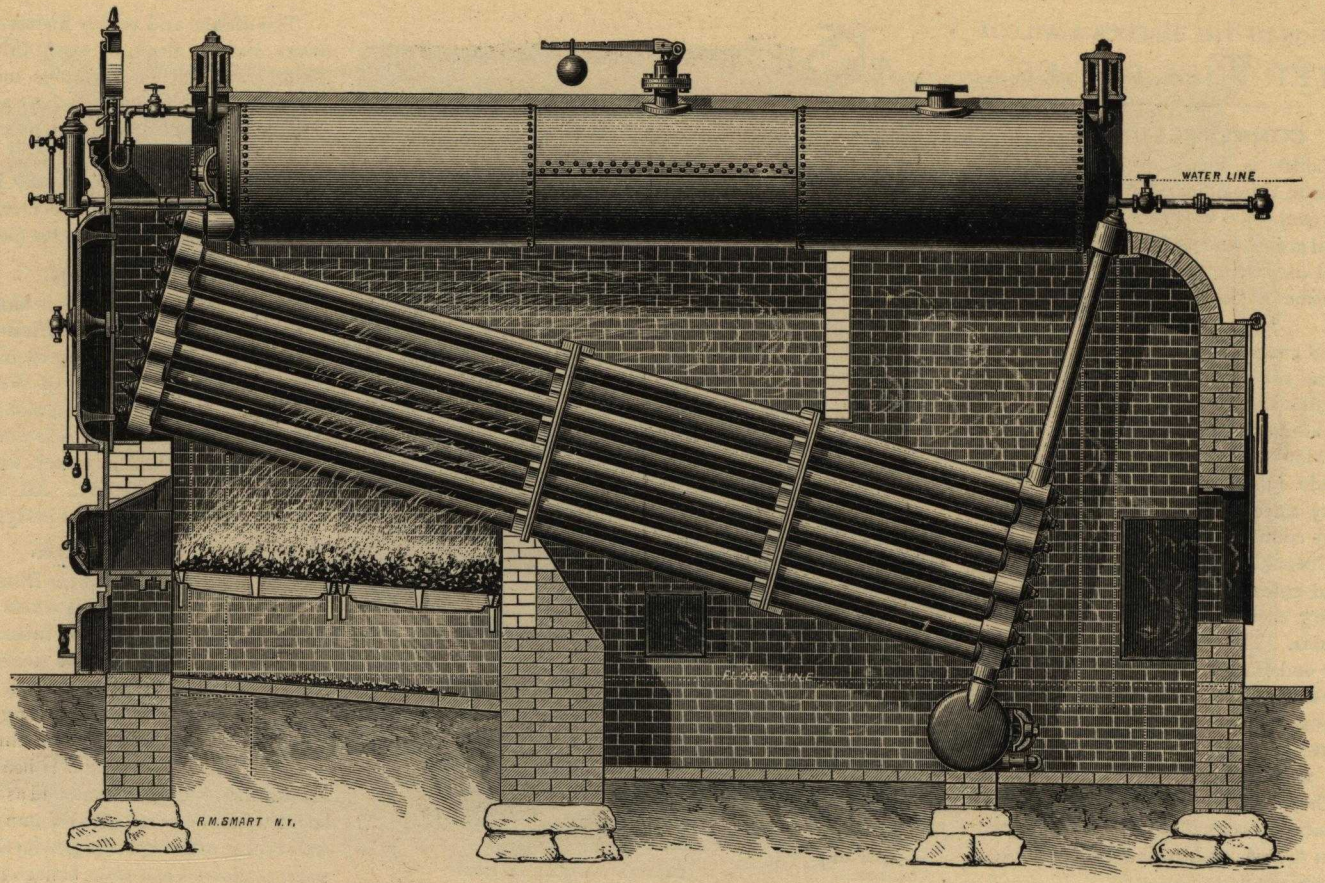
The **mud-drums** are of cast iron, as the best material to withstand corrosion, and are provided with ample means for cleaning.

ERECTION.

In erecting this boiler, it is **suspended entirely independent of the brick-work,** from wrought iron girders resting on iron columns. This avoids any straining of the boiler from unequal expansion between it and its enclosing walls, and permits the brick-work to be repaired or removed, if necessary, without in any way disturbing the boiler. All the **fixtures,** are extra heavy and of neat designs.

OPERATION.

The fire is made under the front and higher end of the tubes, and the products of the combustion pass up between the tubes into a **combustion chamber** under the steam and water-drum; from hence they pass down between the tubes, then once more up through the spaces between the tubes, and off to the chimney. The water inside the tubes, as it is heated, tends to rise towards the higher end, and as it is converted into steam—the mingled column of steam and water being of less specific gravity than the solid water at the back end of the boiler—rises through



Babcock & Wilcox Boiler, 706 H. P., at Raritan Woolen Mills, Raritan, N. J. Erected 1878 and 1881. Side Elevation, showing Ornamental Cast Iron Front and Drum-heads.

the vertical passages into the drum above the tubes where the steam separates from the water and the latter flows back to the rear and down again through the tubes in **a continuous circulation.** As the passages are all large and free, this circulation is very rapid, **sweeping away the steam** as fast as formed, and supplying its place with water; **absorbing the heat** of the fire to the best advantage; causing a **thorough commingling** of the water throughout the boiler and a consequent **equal temperature,** and **preventing, to a great degree, the formation of deposits** or incrustations upon the heating surfaces, sweeping them away and depositing them in the mud-drum, whence they are blown out.

The steam is taken out at the top of the steam-drum near the back end of the boiler after it has thoroughly separated from the water.

ADVANTAGES.

The following are the prominent advantages which this boiler presents over those of the ordinary construction:

1.—Thin Heating Surface in Furnace.

The thick plates necessarily used in ordinary boilers, in the furnace, or immediately exposed to the fire, not only hinder the transmission of heat to the water, but admit of overheating, and even burning the side next the fire, with consequent strains, resulting in loss of strength, cracks, and tendency to rupture. Water tubes, however, admit of **thin envelopes for the water** next the fire, with such ready transmission of heat that even the fiercest fire cannot overheat or injure the surface.

2.—Joints Removed from the Fire.

Riveted joints with their consequent double thickness of metal, in parts exposed to the fire, give rise to serious difficulties. Being the weakest parts of the structure, they concentrate upon themselves all strains of unequal expansion, giving rise to frequent leaks, and not rarely to actual rupture. The joints between tubes and tube sheets also give much trouble when exposed to the direct fire, as in locomotive and tubular boilers. These difficulties are wholly overcome by the use of lap-welded water tubes, with their joints removed from the fire.

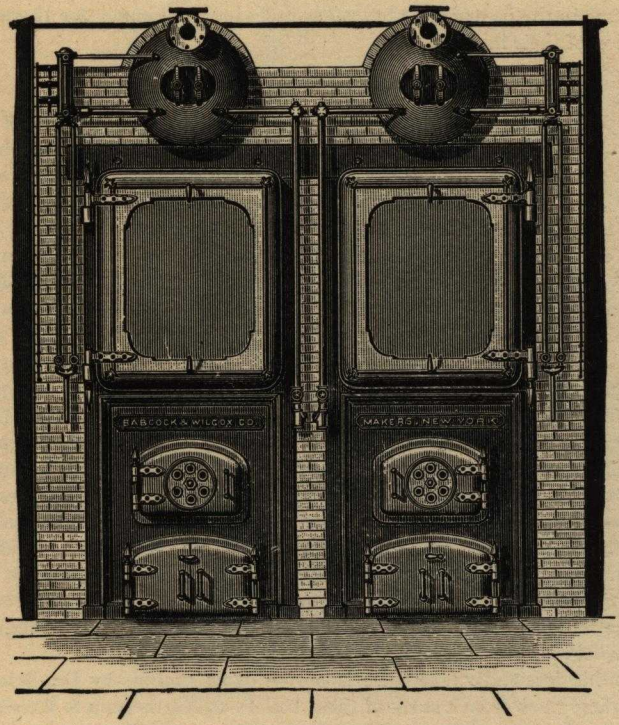
3.—Large Draught Area.

This, which is limited in fire tubes to the actual area of the tubes, in this boiler is the **whole chamber within which the tubes are enclosed,** giving ample time in the passage of the heated gases to the chimney for thorough absorption of their heat.

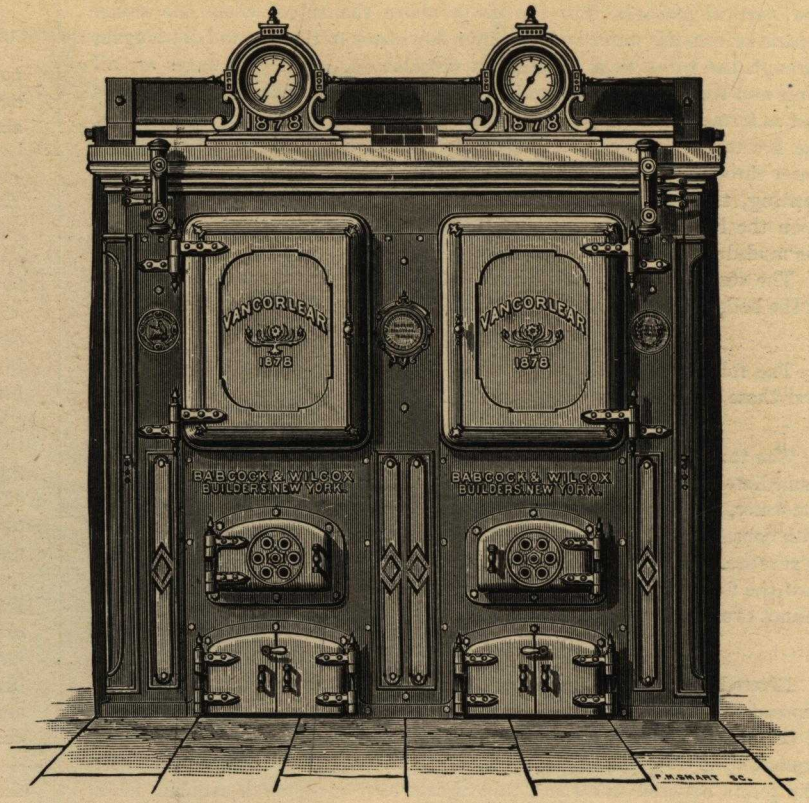
4.—Complete Combustion.

The perfection of combustion depends upon a **thorough mixture** of the gases evolved from the burning fuel with a proper quantity of atmospheric air; but this perfect mixture rarely occurs in ordinary furnaces, as is proven by chemical analysis, and also by the escape of smoke, upon the introduction of any smoke-producing fuel. Even when smoke is not visible, a large percentage of the combustible gases may be escaping into the chimney, in the form of carbonic oxide, or half-burnt carbon. Numerous attempts have been made to cure this evil, by admitting air to the furnace or flues, to "burn the smoke;" but though this may allow so much air to mingle with the smoke as to render it invisible, and at the same time ignite some of the lighter gases, it in reality does little to promote combustion, and the cooling effect of the air more than overbalances all the advantages resulting from the burning gas. The analysis of gases from various furnaces shows almost uniformly an excess of free oxygen, proving that sufficient air is admitted to the furnace, and that a more thorough and perfect *mixing* is needed. Every particle of gas evolved from the fuel should have its equivalent of oxygen, and must find it while hot enough to combine, in order to be effective. In this boiler the current of gases after leaving the furnace are **broken up and thoroughly mingled** by passing between the staggered tubes, and have an opportunity to **complete their combustion** in the triangular chamber between the tubes and drum.

That this does really take place is proved by an analysis by Dr. Behr of the escaping gases from a stack of these boilers at Mattheissen & Weicher's sugar refinery. He made many separate analyses at different times, and **in no case was there more than a trace of carbonic oxide,** even when there was less than one per cent. of uncombined oxygen.



Front of Babcock & Wilcox Boiler, 120 H. P., at the H. I. Kimball House, Atlanta, Ga. Erected 1884. Showing style of Wrought Iron Front.



Front of Babcock & Wilcox Boilers, 120 H. P., at the Vancorlear Apartment House, New York. Erected 1878. Showing style of Ornamental Cast Iron Front.

5.—Thorough Absorption of the Heat.

There are important advantages gained in this respect in consequence of the course of the gases being more nearly at **right angles to the heating surface,** impinging thereon instead of gliding by in parallel lines as in fire-tube boilers. The currents passing **three times across** and between the staggered tubes are brought intimately in contact with all parts of the heating surface, rendering it much more efficient than the same area in ordinary tubular boilers.

The experiments of Doctor Alban and of the U. S. Navy have proved that a given surface arranged in that manner is thirty per cent. more efficacious than when in the form of fire tubes as usually employed.

6.—Efficient Circulation of Water.

As **all the water in the boiler tends to circulate in one direction,** there are no interfering currents, the steam is carried quickly to the surface, all parts of the boiler are kept at a nearly equal temperature, preventing unequal strains, and by the rapid sweeping current the tendency to deposit sediment on the heating surface is materially lessened.

7.—Quick Steaming.

The water being divided into many small streams, in thin envelopes, passing through the hottest part of the furnace, steam may be **rapidly raised** in starting, and sudden demands upon the boiler may be met by a **quickly increased** efficiency.

8.—Dryness of Steam.

The large disengaging surface of the water in the drum, together with the fact that the steam is delivered at one end and taken out at the other, secures a **thorough separation of the steam from the water,** even when the boiler is forced to its utmost. Most tubular, locomotive and sectional boilers make wet steam, "priming" or "foaming," as it is called, and in many "super-heating surface" is provided to "dry the steam;" but such surface is always a source of trouble, and is incapable of being graduated to the varying requirements of the steam. Hence a boiler which **makes** dry steam is to be preferred to one that **dries** steam which has been made wet.

9.—Steadiness of Water Level.

The large area of surface at the water line, and the ample passages for circulation secure a steadiness of water level not surpassed by any boiler.

10.—Freedom for Expansion.

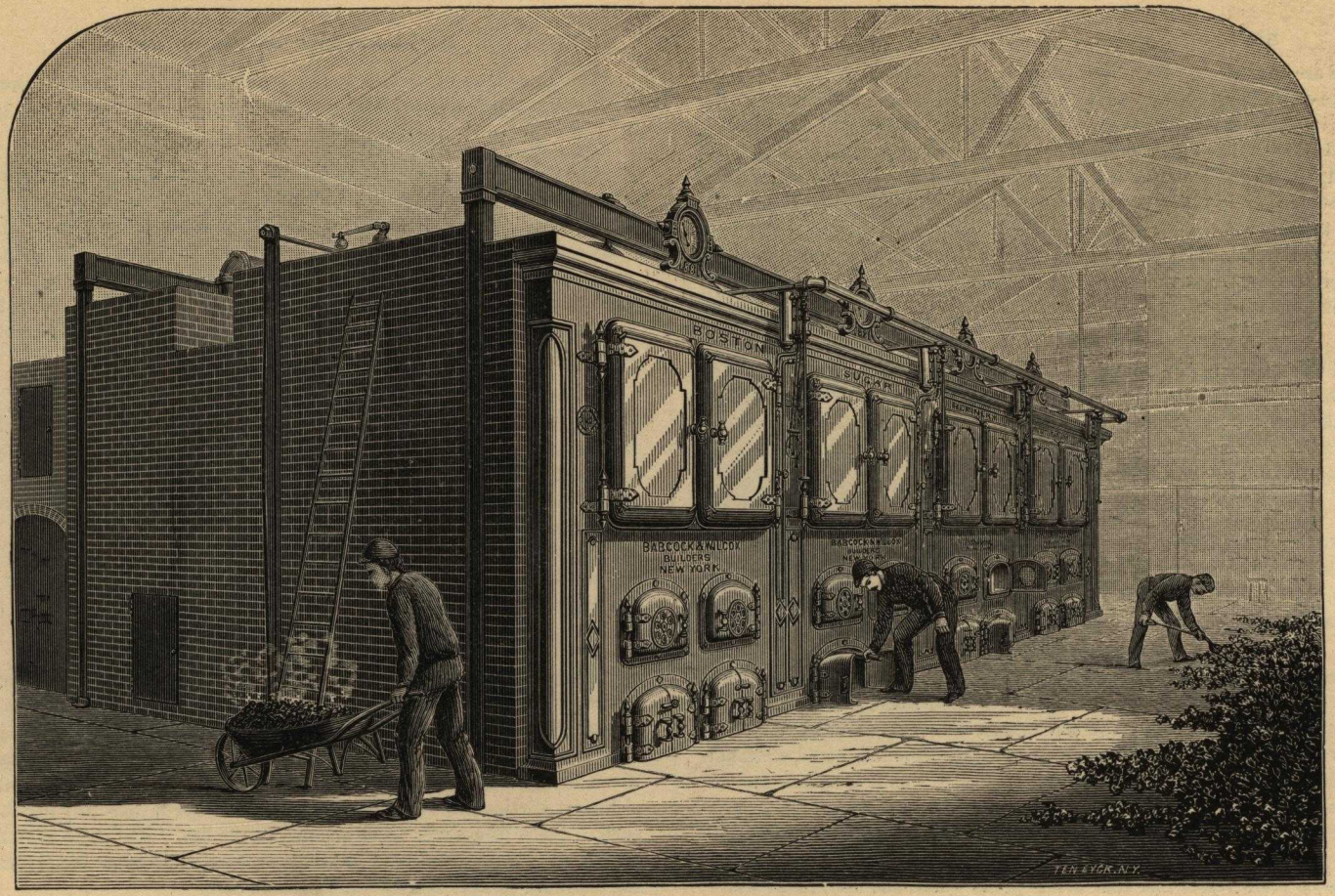
The triangular arrangement of the parts forming **a flexible structure** allows any member to expand without straining any other, the expanded connections being also **amply elastic** to meet all necessities of this kind. This is of great importance because the weakening effect of these strains of unequal expansion, between rigidly connected parts, is a prolific cause of explosions in ordinary boilers. The rapid circulation of the water, however in this boiler, by keeping all parts at the same temperature, prevents to large extent unequal expansion.

11.—Safety from Explosions.

The **freedom from unequal expansion** avoids the most frequent cause of explosions, while the division of the water into **small masses** prevents serious destructive effects in case of accidental rupture. The comparatively **small diameter** of the parts secures, even with thinness of surface, **great excess of strength** over any pressure which it is desirable to use. So powerful is the circulation of the water, that no part will be uncovered to the fire until the quantity of water in the boiler is so far reduced that if overheating should occur no explosion could result.

12.—Durability.

Besides the important increase of durability due to the absence of deteriorating strains, and of thick plates and joints in the fire, there is no portion of the boiler exposed to the abrasive action which so rapidly destroys the ends of fire tubes, or to the blow-pipe action of the flame upon the crown sheet, bridge walls and tube sheets, which are so destructive frequently to ordinary, particularly locomotive boilers. Neither is there any portion of the surface above the water level exposed to the fire. For these reasons these boilers are durable, and **less liable to repairs,** than other boilers under the same circumstances, and having the same care.



Babcock & Wilcox Boilers at Boston Sugar Refinery, East Boston, Mass. 1000 H. P. Erected 1880.

Showing style of Fronts for continuous batteries of boilers.

13.—Accessibility for Cleaning.

This is of the greatest importance and is secured to **the fullest extent.** Hand-holes, with metal joints, opposite each end of each tube permit access thereto for cleaning, and a man-hole in the steam and water drum, and hand-holes in mud-drum are provided for the same purpose. **All portions** of both the exterior and interior surface are **fully accessible** or cleaning. The occasional use of steam through a blowing pipe attached to a rubber hose operated through doors in the side walls, will keep the tubes free from soot and in condition to receive the heat to the best advantage.

14.—Least Loss of Effect from Dust.

WATER-TUBE.

The ordinary fire tube, or flue, receiving the dust from the fire on the interior is quickly covered from one-third to one-half its surface, and in time is completely filled. The water-tube, however, will retain but a limited quantity on its upper side, after which it becomes in a measure self cleaning.

FIRE-TUBE.

15.—Ease of Transportation.

Being made in sections, which are readily put together with a simple expanding tool, these boilers may be easily and cheaply transported where it would be wholly impossible to place a boiler of ordinary construction. They can be made in parts small enough for **mule transportation,** if required.

16.—Repairs.

As now constructed these boilers seldom require repairs, but should, from any cause, such be necessary, any good mechanic can make them with the tools usually found in boiler shops. Should a tube require to be renewed it can be removed, and a new one substituted the same as in a tubular boiler.

17.—Capacity.

This is a point of the greatest importance, and upon it depends, in a large measure, the satisfactory performance of any boiler in several particulars. Unless **sufficient steam and water capacity** is provided there will not be regularity of action; the steam pressure will suddenly rise and as suddenly fall, and the water level will be subject to frequent and rapid changes; and if the steam is drawn suddenly from the boiler, or the boiler crowded, wet steam will result.

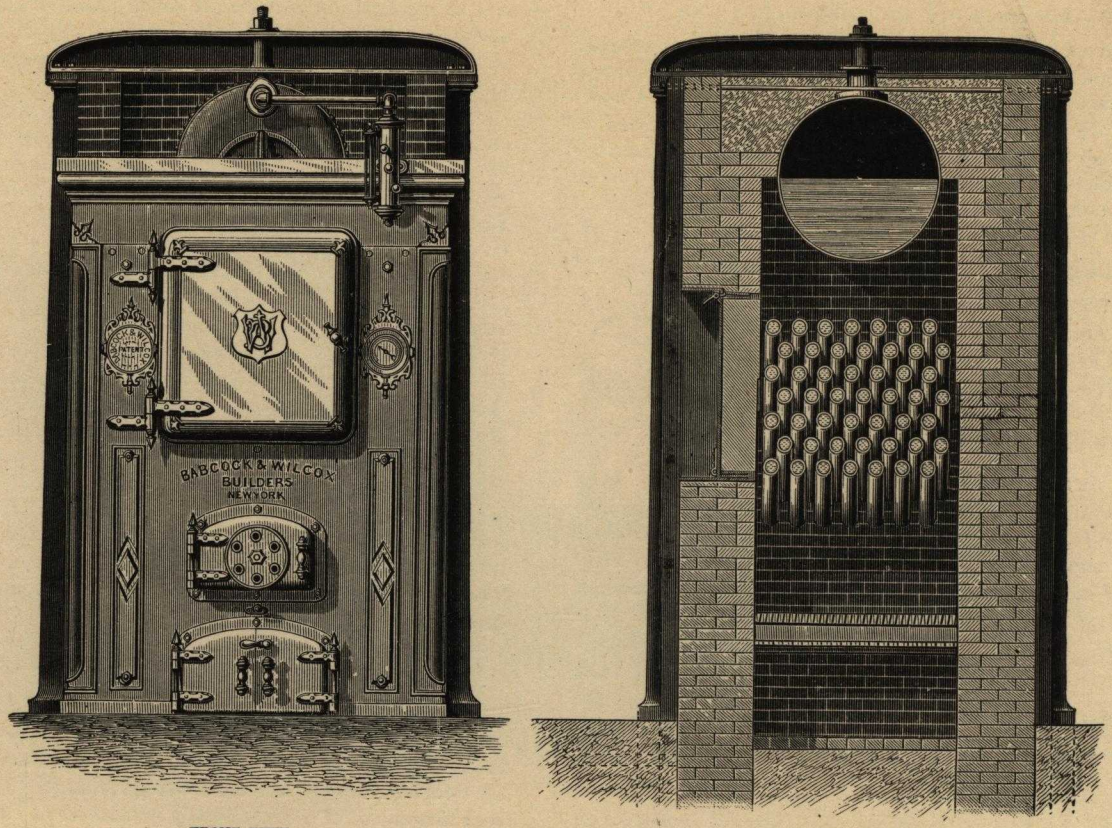
Water capacity is of more importance than steam space, owing to the small relative weight of the steam. *Twenty-three* cubic feet of steam, or *one* foot of water space, are required to supply *one horse-power for one minute*, the pressure, meantime falling from 80 lbs. to 70 lbs. per square inch. The value of large steam room is therefore generally much overrated, but if it be too small, the steam in passing off will sweep the water with it in the form of spray. Too much water space makes slow steaming and waste of fuel in starting. To much steam space adds to the radiating surface and increases the losses from that cause.

The **proportions of this boiler** have been adopted after numerous experiments with boilers of varying capacity; and experience has established that this boiler can be driven to the utmost, carrying a **steady water level, and steam pressure,** and **always furnishing dry steam.**

The **cubical capacity** of this boiler, per horse power, is equal to that of the best practice in tubular boilers of the ordinary construction. The fire surface being of the most effective character, these boilers will, with good fuel and a reasonably economical engine, greatly exceed their rated power, though it is seldom economy to work a boiler above its nominal power. The **space occupied** by this boiler and setting is equal to about **two-thirds** that of the same power in tubular boilers.

18.—Practical Experience.

The above advantages would be worthy of attention if they were only theoretical, but they have been, in fact, demonstrated by the **experience of fifteen years,** under a great variety of circumstances and of treatment. Of the total number sold, **less than two per cent.** have, so far as we are aware, been thrown out of use; while a large number of customers have **repeated their orders**—some a score of times,—as will be seen by the list of references hereto appended.



FRONT VIEW.

VERTICAL SECTION.

75 H. P. Babcock & Wilcox Boiler, at T. A. Edison's Laboratory, Menlo Park, N. J. Erected 1878.

Showing style of Fronts for single boilers.

ECONOMY IN STEAM.

EFFICIENCY OF THE BOILER.

One pound of pure carbon when burned yields 14,500 heat units, each of which is equal to 772 foot pounds of energy. One pound of carbon, if all its heat was utilized in power, would therefore exert 5.65 horse-power for one hour, instead of from ½ to ¼, as in the best ordinary practice. The 14,500 heat units would, if all utilized in a boiler, evaporate 15 pounds of water from 212° at atmospheric pressure. A boiler which evaporates 7½ pounds of water for each pound of combustible, utilizes but 50 per cent. of the total heat, and this is about the average result of shell boilers now in use.

The Babcock & Wilcox boilers, in an average of twenty tests by fourteen different engineers in widely-separated places, and under a variety of circumstances, most of them being in regular practical work, and some of them on boilers which had been in daily use for years, gave an evaporation of 11.34 lbs. water per pound of combustible, or 10,952 heat units utilized, which is **75½ per cent. of the total heat.** In special cases they have utilized as high as 82 per cent., and, as about 15 per cent. is necessarily lost in the chimney gases, and in radiation, little higher results can be looked for; and it is therefore evident that all claims to over 12½ lbs. evaporation should be looked upon as unreliable.

It is never economy to force a boiler, and the best results are always attained with ample boiler power. It is also necessary to keep the boiler clean and in good order, and to have careful firing where economy is desired.

EFFICIENCY OF THE ENGINE.

A first-class boiler will deliver to the engine 75 per cent. of all the energy in the combustible, or say 10,875 out of a total of 14,500 heat units, or, allowing about 8 per cent. for ashes, 10,000 heat units for each pound of coal burned. This represents 7,720,000 foot pounds of energy, which, if all utilized by the engine, would give 3.90 horse-power for one hour, or at the rate of 0.26 lbs. coal for each hourly horse-power. But, by the greatest refinement in engines yet accomplished, the cost of a horse-power has not been brought below 1½ lbs. coal per hour, or 17 per cent. of the energy delivered by the boiler, while the average engine uses 3½ lbs. coal per horse-power, and discharges, unutilized, 93 per cent. of the energy delivered to it! The greater part of this loss is in the latent heat of the steam, which is exhausted into the atmosphere, or condenser, and is unavoidable so far as now known. Still, the fact remains that many an ordinary engine uses four times as much steam for the same power as is required by the best engines.

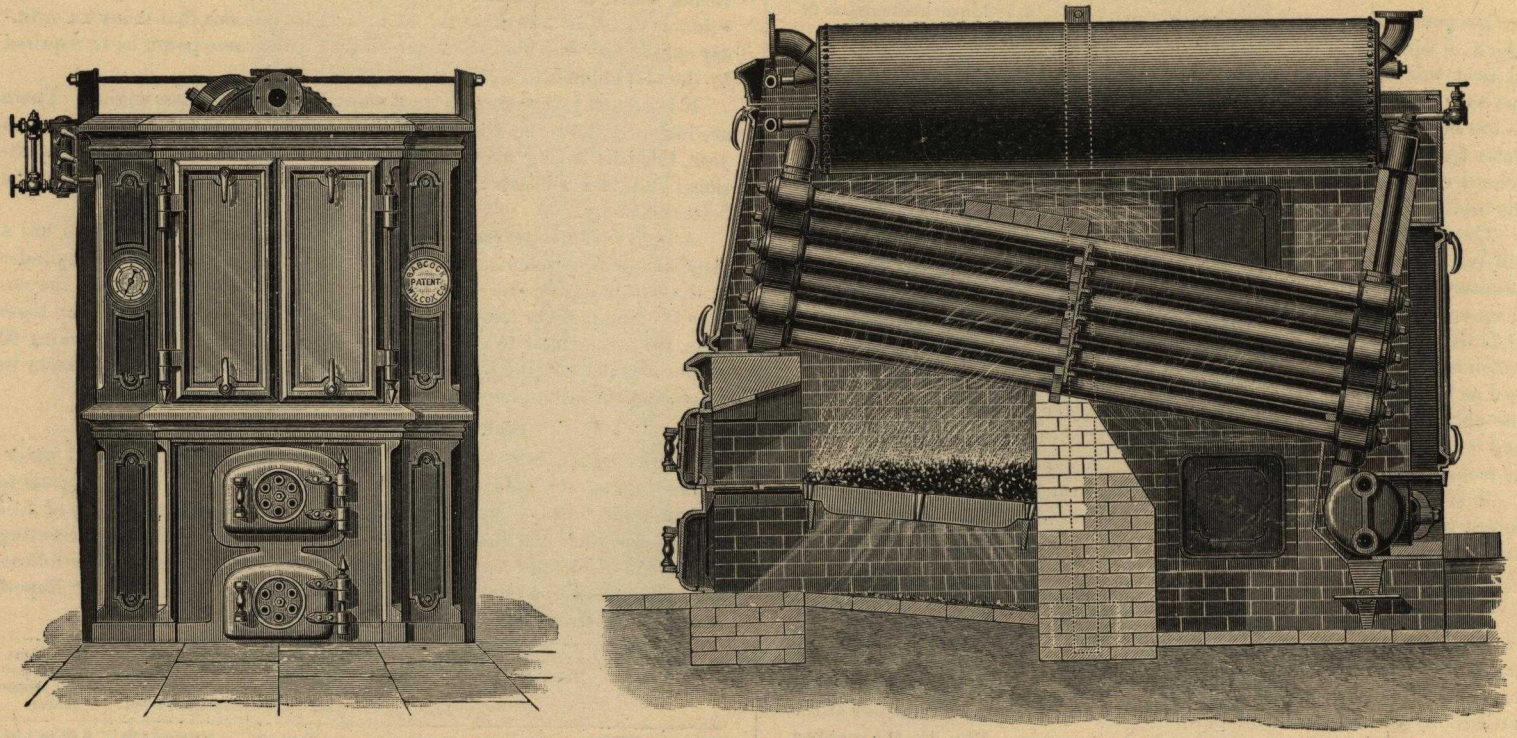
It is economy, therefore, in most cases, to use a high-class engine. There are instances, however, where the engine is used for so short a time in each year, that the saving may not be sufficient to pay the interest on the additional cost, and a cheaper engine, even if comparatively wasteful, may be better economy.

A large boiler is generally an advantage, but it is not economy to use a large engine to develop a small power. Sufficient steam to fill the cylinder at the terminal pressure—each stroke—has to be furnished whether the engine is doing more or less work, and this frequently amounts to far more than the steam used to do the work. Thus, a 24 × 48 engine, making 60 revolutions per minute, without "cut-off," uses 30 horse-power of steam in displacing the atmosphere, without exerting any available power.

EFFICIENCY OF PUMPING MACHINES.

Many engines, from the small "donkey" feed pump to the great waterworks engine, are used exclusively for pumping water, and it is usual to reckon their "duty" by the water pumped, expressed in millions of foot pounds for each 100 lbs. coal burned, each million of duty representing about 0.13 of one per cent. of the thermal value of the steam. The following table is based on one given by Chas. E. Emery, Ph. D., in the "Report and Awards, Group XX, U. S. Centennial Exposition":

Description.	Duty in Million Foot Pounds per 100 lbs. Coal.	Per Centage of Thermal Value of Steam Used.	Equivalent in Coal per Hourly Horse-power.
Pumping Engines	30 to 110	3.89 to 13.25	6.68 to 1.95
Steam pumps, large size, proportioned for work	15 " 30	1.94 " 3.89	13.4 " 6.68
Steam pumps, small size for ordinary uses	8 " 15	1 04 " 1.94	25 " 13.4
Vacuum pumps	3 " 10	0.39 " 1.30	66.6 " 25
Injectors, lifting water only	2 " 5	0.26 " 0.65	100 " 66.6



Babcock & Wilcox Boiler 35 H. P., in Public School Building, Plainfield, N. J. Erected 1883.

HORSE-POWER OF BOILERS.

Strictly speaking, there is no such thing as "horse-power" to a steam boiler; it is a measure applicable only to dynamic effect. But as boilers are necessary to drive steam-engines, the same measure applied to steam-engines has come to be universally applied to the boiler, and cannot well be discarded. In consequence, however, of the different quantity of steam necessary to produce a horse-power, with different engines, there has been great need of an accepted standard by which the amount of boiler required to provide steam for a commercial horse-power may be determincd.

This standard, as fixed by Watt, was one cubic foot of water evaporated per hour from 212° for each horse-power. This was, at that time, the requirement of the best engine in use. At the present time Prof. Thurston estimates, that the water required per hour, per horse-power, in good engines is equal to the constant 200, divided by the square root of the pressure, and that in the best engines this constant is as low as 150. This would give for good engines, working with 64 lbs. pressure, 25 lbs. water, and for the best engines working with 100 lbs., only 15 lbs. water per hourly horse-power.

The extensive series of experiments, made under the direction of C. E. Emery, Esq., at the Novelty Works, in 1866–8, and published by Professor Trowbridge, show, that at ordinary pressures, and with good proportions, non-condensing engines of from 20 to 300 H. P., required only from 25 to 30 lbs. water per hourly horse-power, in regular practice.

The standard, therefore, adopted by the judges at the late Centennial Exhibition, of **30 lbs. water per hour**, evaporated, at 70 lbs. pressure, from 100°, for each horse-power, is a fair one for both boilers and engines, and has been favorably received by engineers and steam users, but as the same boiler may be made to do more or less work with less or greater economy, it should be also required that the rating of a boiler be based on **the amount of water it will evaporate at a high economical rate.**

Square feet of heating surface is no criterion as between different styles of boilers—a square foot under some circumstances being many times as efficient as in others; but when an average rate of evaporation per square foot for any given boiler has been fixed upon by experiment, there is no more convenient way of rating the power of others of the same style. The following table gives an approximate list of square feet of heating surface per H. P. in different styles of boilers; the rate of combustion of coal per hour, per square foot of fire surface, required for that rating; the relative economy, and the rapidity of steaming:—

Type of Boiler.	Sq. ft. for One H. P.	Coal for each sq. ft.	Relative Economy.	Relative Rapidity of Steaming.	Authority.
Water-tube	10 to 12	.3	1.00	1.00	Isherwood.
Tubular	14 to 18	.25	.91	.50	"
Flue	8 to 12	.4	.79	.25	Prof. Trowbridge.
Plain Cylinder	6 to 10	.5	.69	.20	"
Locomotive	12 to 16	.275	.85	.55	
Vertical Tubular	15 to 20	.25	.80	.60	

A Horse-Power in a steam-engine or other prime mover, is 550 lbs. raised 1 foot per second, or 33,000 lbs. 1 foot per minute.

HORSE-POWER OF DIFFERENT NATIONS.

Most nations have a standard for power similar to, and generally derived from Watt's "horse-power," but owing to different standards of weights and measures, these are not identical, though the greatest differences amount to less than 1½ per cent. The following table gives the standard horse-power for each nation, in *kilogrammetres per second*, and in *foot-pounds per second*, expressed in the foot and pound standard in each country.

TABLE OF STANDARD HORSE-POWER FOR DIFFERENT NATIONS.

Country.	Kilogrammetres per sec.	Baden Ft pounds, per sec.	Saxon Ft. pounds, per sec.	Wortemberg. Ft. pounds, per sec.	Prussian Ft. pounds, per sec.	Hanovarian Ft. pounds, per sec.	English Ft. pounds, per sec.	Austrian Ft. pounds, per sec.
France and Baden	**75.**	**500.**	529.68	521.58	477.93	513.53	512.47	423.68
Saxony	75.045	500.30	**530.**	523.89	478.22	513.84	542.80	423.93
Wortemberg	75.240	501.36	531.12	**525.**	479.23	514.92	543.95	424.83
Prussia	75.325	502.17	531.97	525.85	**480.**	515.75	544.82	425.51
Hanover	75.361	502.41	532 23	526.10	480.23	**516.**	545.08	425.72
England	76.041	506.94	537.03	530.84	484.56	520.65	**550.**	429.56
Austria	76.119	507.46	537.58	531.39	485.06	521.19	550.57	**430.**

Babcock & Wilcox Boilers 488 H. P., in The New York Mutual Life Insurance Co's Building, New York City. Erected 1884, beneath Court Yard.

PRIMING OR WET STEAM.

A fault frequently met with in steam boilers is the carrying over of water mechanically mixed with the steam, which water not only carries away heat without any useful effect, but, when present in any marked quantity, itself becomes a source of danger and of serious loss in the engine. Many boilers show a high apparent evaporation in consequence of furnishing "wet steam," while practically they are anything but economical. Parties have been known to claim an evaporation of 19 to 20 pounds per pound of coal, where the highest practically possible is not over 13. Such boilers are dear at any price.

The cause of priming may be either impure water, too much water, or improper proportions in the boiler. When a boiler is found to form wet steam with good water, carried at a proper height, it is a proof of wrong design.

The amount of priming in different boilers varies greatly, and as yet there is not sufficient data to establish any definite ratio for boilers in ordinary use. The experiments of M. Hirn, at Mulhouse, showed an average of at least 5 per cent.; Zeuner sets it down as approximately from 7½ to 15 per cent.; the careful experiments at the American Institute in 1871 show in cylindrical tubulars 7.9 per cent., and in the tests at the Centennial Exposition one boiler showed as high as 18.57 per cent. priming. An amount of 3 to 4 per cent. of moisture in steam cannot be detected by ordinary observation, and steam containing no more than that amount may be termed "commercially dry."

The common method of determining the per centage of moisture in steam is described in the report of the test of Babcock & Wilcox boilers at the Raritan Woolen Mill, on a subsequent page. If experiments of this kind are not made with great care by experienced hands, and with instruments of the utmost accuracy, they are liable to such errors as to render them worthless. Fuller directions for this purpose, and the difficulties in securing accuracy in such tests, will be found in the Report of the Committee on Boiler Tests, in Vol. VI. of the Transactions of the American Society of Mechanical Engineers.

SUPERHEATED STEAM.

Steam which has a higher temperature than that normal to its pressure, is termed "superheated" or "gaseous." Dr. Seimens found that when steam at 212° was heated separate from water it increased rapidly in volume up to 230°, after which it expanded uniformly as a permanent gas. If this superheating could be carried to such an extent as to avoid the "initial condensation" within the cylinder of an engine, there would be a marked economy in its use, but this involves so high a temperature as to burn the lubricating material and destroy the engine in a short time. For other purposes the use of superheated steam adds little, if anything, to the economy, while it greatly increases the cost and the wear and tear. Where superheating is required it should always be done by a separate apparatus, and pains must be taken to separate the entrained water from the steam before it enters the superheater. The use in any steam boiler of superheating surface exposed to the heated gases of combustion, is highly objectionable, and is of doubtful efficiency. Steam cannot be superheated when in contact with water.

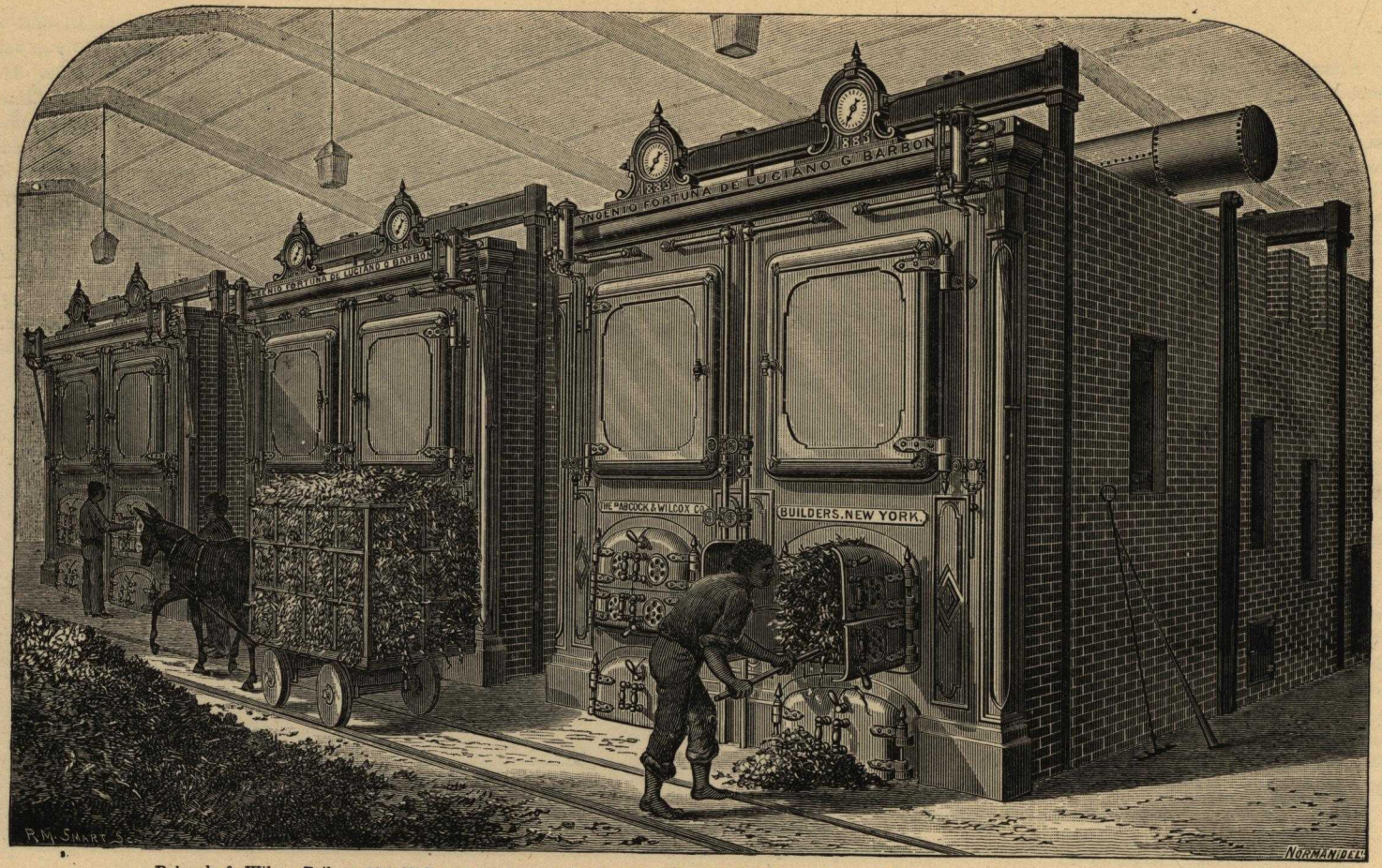
TEMPERATURE OF FIRE.

By reference to the table of fuels, it will be seen that the temperature of the fire is nearly the same for all kinds of combustibles, under similar conditions. If the temperature is known, the conditions of combustion may be inferred. The following table, from M. POUILLET, will enable the temperature to be judged by the appearance of the fire :

Appearance.	Temp. Fah.	Appearance.	Temp. Fah.
Red, just visible	977°	Orange, deep	2010
" dull	1290	" clear	2190
" Cherry, dull	1470	White heat	2370
" " full	1650	" bright	2550
" " clear	1830	" dazzling	2730

To determine temperature by fusion of metals, etc.—

Substance.	Temp. Fah.	Metal.	Temp. Fah.	Metal.	Temp. Fah.
Tallow	92°	Bismuth	518	Silver, pure	1830
Spermaceti	120	Lead	630	Gold Coin	2156
Wax, white.	154	Zinc	793	Iron Cast, medm.	2010
Sulphur	239	Antimony	810	Steel	2550
Tin	455	Brass	1650	Wrought Iron	2910



Babcock & Wilcox Boilers, 624 H. P., at the Ingenio Fortuna de Luciano G. Barbon, Alquizar, Cuba. Erected in 1883, for burning bagasse

BOILER EFFICIENCY.

A steam generator is composed of two distinct parts, each with its independent function. **The furnace** is for the proper combustion of the fuel, and its duty is performed to perfection when the greatest amount, but not necessarily *intensity*, of heat is obtained from the given weight of combustible. **The boiler** proper is for the transfer of the heat thus generated into useful effect by evaporating water into steam, and its function is fulfilled completely when the greatest possible quantity of heat is thus utilized. To a lack of appreciation of this fact, and of a knowledge of the principles involved, is chargeable much waste of money and disappointment, both to inventors and steam users.

As a boiler is for making steam, it can only utilize for that purpose heat of a greater intensity or higher temperature than the steam itself, therefore the gases of combustion cannot be reduced below that temperature, and the heat thereby represented is lost. The amount of this loss will depend upon the amount of air admitted to the furnace, and the increase of temperature at which it escapes. **The more air admitted the greater the loss;** hence the fallacy of all those schemes which admit air above the fire.

The rate of combustion should not exceed 0.3 pound of coal per hour per square foot of heating surface, except where *quantity* of steam is of greater importance than economy of fuel. Where a blast is used the grate surface should be proportionately reduced to secure best economy.

"The maximum conductivity or flow of heat is secured by so designing the boiler as to secure rapid, steady, and complete circulation of the water within it . . . . and securing opposite directions of flow for the gases on the one side and the water on the other."—*Prof. R. H. Thurston.*

The accumulation of scale on the interior, and of soot on the exterior, will seriously affect the efficiency and economy of the boiler. Only one-eighth of an inch deposit of soot renders the heating surface practically useless. Only one-sixteenth of an inch of scale or sediment will cause a loss of 13 per cent. in fuel. A boiler must therefore be **kept clean, outside and in,** to secure a high efficiency.

The result of a bad setting for a boiler has been known to be a loss of 21 per cent. in economy.

FURNACE EFFICIENCY.

Combustion may be defined as "the union of two dissimilar substances, evolving light and heat." In ordinary practice, one of these is always the oxygen in the atmosphere, and the other is the fuel employed. Every pound of fuel requires a given quantity of oxygen for its complete combustion, and thus a given quantity of air. This varies with different fuels, but in every case less air prevents complete combustion, and **an excess of air causes waste of heat** to the amount required to heat it to the temperature of the escaping gas.

With chimney draft, the experiments of the U. S. Navy show that ordinary furnaces require about twice the theoretical amount of air to secure perfect combustion.

Prof. Schwackhoffer, of Vienna, found in the boilers used in Europe an average excess of 70 per cent. of the total amount passing through the fire —or that over three times the theoretical amount was used.

A series of analyses by Dr. Behr of the escaping gases from a Babcock & Wilcox boiler, with chimney draft, showed an average excess of air equal to 48 per cent. of the whole quantity.

A series of 12 tests made by same with artificial blast, gave an average excess of only 22 per cent. of the whole quantity, and in a few cases none at all, with only traces of carbonic oxide, showing perfect combustion.

In a summary of experiments made in England, published in Bourne's late large work, "Steam, Air and Gas Engines," it is stated that:—

"A moderately thick and hot fire with rapid draft uniformly gave the best results."

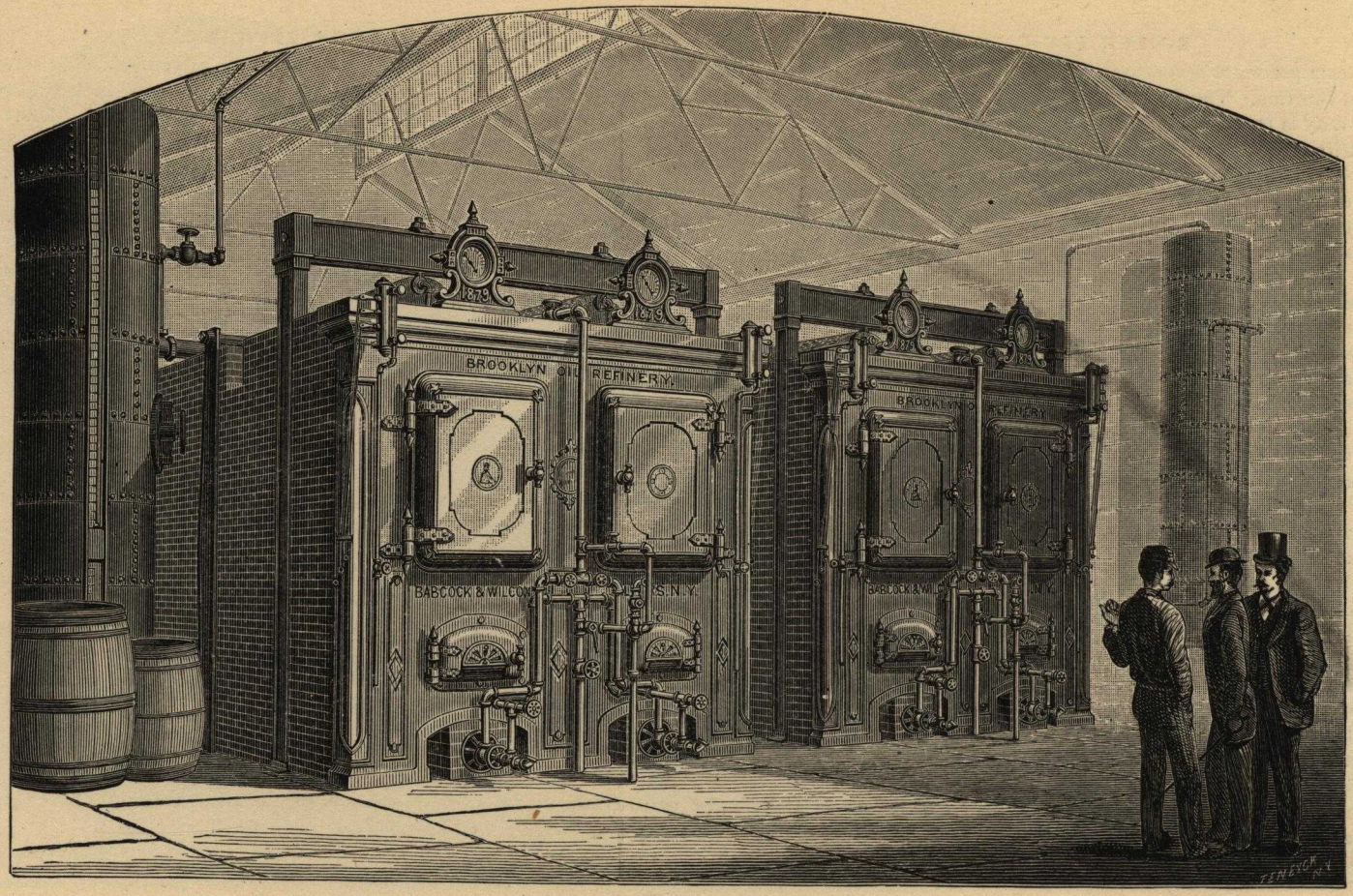
"Combustion of black smoke by additional air was a loss."

"In all experiments the highest result was always obtained when all the air was introduced through the fire bars."

"Difference in mode of firing only, may produce a difference of 13 per cent." (in economy).

Different fuels require different furnaces, and no one furnace or grate-bar is equally good for all fuels.

The Babcock & Wilcox Co. provide with their boilers, a **special furnace,** adapted to the particular kind of fuel to be used.



400 H. P. Babcock & Wilcox Boilers at Standard Oil Co's Brooklyn Oil Refinery. Erected in 1878. With Apparatus for burning Tar or Petroleum.

FUEL.

The value of any fuel is measured by the number of heat units which its combustion will generate, a unit of heat being the amount required to heat one pound of water one degree Fahrenheit. The fuel used in generating steam is composed of carbon and hydrogen, and ash, with sometimes small quantities of other substances not materially affecting its value.

"Combustible" is that portion which will burn; the ash or residue varying from 2 to 36 per cent. in different fuels.

TABLE OF COMBUSTIBLES.

Kind of Combustible.	Air Required.	Temperature of Combustion.				Theoretical Value.		Highest Attainable Value under Boiler.	
	In Pounds per pound of Combustible.	With Theoretical Supply of Air.	With 1½ Times the Theoretical Supply of Air.	With Twice the Theoretical Supply of Air.	With Three Times the Theoretical Supply of Air.	In Pounds of Water raised 1° per pound of Combustible.	In Pounds of Water evaporated from and at 212°, with 1 lb. Combustible.	With Chimney Draft.	With Blast, Theoretical Supply of Air at 60°, Gas 320°.
Hydrogen	36.00	5750	3860	2860	1940	62032	64.20		
Petroleum	15.43	5050	3515	2710	1850	21000	21.74	18.55	19.90
Carbon—Charcoal, Coke, Anthracite Coal,	12.13	4580	3215	2440	1650	14500	15.00	13.30	14.14
Coal—Cumberland	12.06	4900	3360	2550	1730	15370	15.90	14.28	15.06
" Coking Bituminous	11.73	5140	3520	2680	1810	15837	16.00	14.45	15.19
" Cannel	11.80	4850	3330	2540	1720	15080	15.60	14.01	14.76
" Lignite	9.30	4600	3210	2490	1670	11745	12.15	10.78	11.46
Peat—Kiln dried	7.68	4470	3140	2420	1660	9660	10.00	8.92	9.42
" Air dried, 25 per cent. water	5.76	4000	2820	2240	1550	7000	7.25	6.41	6.78
Wood—Kiln dried	6.00	4080	2910	2260	1530	7245	7.50	6.64	7.02
" Air dried, 20 per cent. water	4.80	3700	2670	2100	1490	5600	5.80	4.08	4.39

The above table gives, for the more common combustibles, the air required for complete combustion, the temperature with different proportions of air, the theoretical value, and the highest attainable value under a steam boiler, assuming that the gases pass off at 320°, the temperature of steam at 75 lbs. pressure, and the incoming draft to be at 60°; also that with chimney draft twice and with blast only, the theoretical amount of air is required for combustion.

The effective value of all kinds of wood *per pound*, when dry, is substantially the same. The following are the weights and comparative value of different woods by the cord:

Kind of Wood.	Weight.	Kind of Wood.	Weight.	Kind of Wood.	Weight.
Hickory, Shell bark.	4469	Beech	3126	Spruce	2325
" Red heart.	3705	Hard Maple	2878	New Jersey Pine	2137
White Oak	3821	Southern Pine	3375	Yellow Pine	1904
Red Oak	3254	Virginia "	2680	White "	1868

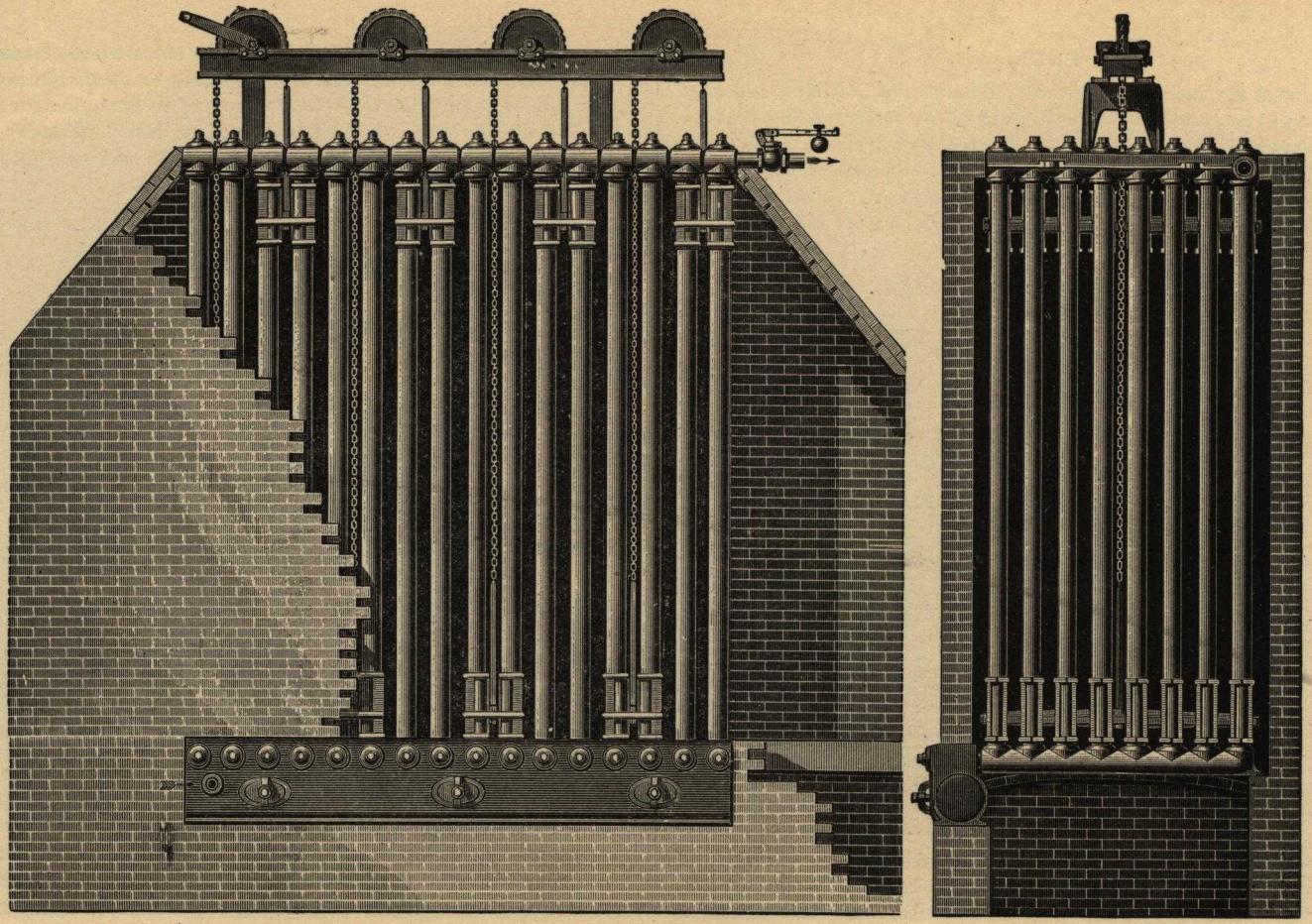
The following table of American coals has been compiled from various sources:

AMERICAN COALS.

State.	Kind of Coal.	Per cent. of Ash.	Theoretical Value: in Heat Units.	Theoretical Value: in Pounds of water evap.
Penn.	Anthracite	3.49	14,199	14.70
"	"	6.13	13,535	14.01
"	"	2.90	14,221	14.72
"	Cannel	15.02	13,143	13.60
"	Connellsville	6.50	13,368	13.84
"	Semi-bi'nous	10.77	13,155	13.62
"	Stone's Gas	5.00	14,021	14.51
"	Youghiogheny	5.60	14,265	14.76
"	Brown	9.50	12,324	12.75
Kentucky	Caking	2.75	14,391	14.89
"	Cannel	2.00	15,198	16.76
"	"	14.80	13,360	13.84
"	Lignite	7.00	9,326	9.65
Ill.	Bureau Co.	5.20	13,025	13.48
"	Mercer Co.	5.60	13,123	13.58
"	Montauk	5.50	12,659	13.10
Ind.	Block	2.50	13,588	14.38
"	Caking	5.66	14,146	14.64
"	Cannel	6.00	13,097	13.56
Md.	Cumberland	13.98	12,226	12.65
Ark.	Lignite	5.00	9,215	9.54
Col	"	9.25	13,562	14.04
"	"	4.50	13,866	14.35
Texas	"	4.50	12,962	13.41
Wash. Ter.	"	3.40	11,551	11.96
Penn.	Petroleum		20,746	21.47

"Slack" or the screenings from coal, when properly mixed—anthracite and bituminous,—and burned by means of a blower on a grate adapted to it, is nearly equal in value of combustible to coal, but its percentage of refuse is greater.

A number of firms are using slack with decided economy, under Babcock & Wilcox boilers, in which there is ample space below the tubes for the dust to accumulate without covering heating surface or impairing the draft.



Babcock & Wilcox Patent Fuel Economizer, at Bound Brook Woolen Mills, Bound Brook, N. J. 300 H. P. Boilers. Erected 1879.

FUEL ECONOMIZERS.

There are two sources of waste in all steam boilers which may in a measure be made to neutralize each other. The gases going to the chimney carry off on an average, according to good authority, 31 per cent. of the fuel, and in the most economical boiler this cannot be reduced below 12 per cent. The feed-water, on the other hand, has to be heated from the normal temperature to that of the steam before evaporation can commence, and this generally at the expense of the fuel which should be utilized in making steam. This temperature at 75 lbs. pressure is 320°, and if we take 60° as the average temperature of feed, we have 260 units of heat per pound which, as it takes 1151 units to evaporate a pound from 60°, represents a loss of 22.5 per cent. of fuel. All of this heat therefore which can be imparted to the feed-water from the waste heat in the escaping gases, is just so much saved. The following table gives the percentage of saving under different conditions:

PERCENTAGE OF SAVING OF FUEL BY HEATING FEED-WATER.

(Steam at 60 lbs.)

Final Temperature.	INITIAL TEMPERATURE OF WATER.												
	32°	40°	50°	60°	70°	80°	90°	100°	120°	140°	160°	180°	200°
60°	2.39	1.71	0.86	0									
80	4.09	3.43	2.59	1 74	0.88	0							
100	5.79	5.14	4.32	3.49	2.64	1.77	0.90	0					
120	7.50	6.85	6.05	5.23	4.40	3.55	2.68	1.80	0				
140	9.20	8.57	7.77	6.97	6.15	5.32	4.47	3.61	1.84	0			
160	10.90	10.28	9.50	8.72	7.91	7.09	6.26	5.42	3.67	1.87	0		
180	12.60	12.00	11.23	10.46	9.68	8.87	8.06	7.23	5.52	3.75	1.91	0	
200	14.30	13.71	13.00	12.20	11.43	10.65	9.85	9.03	7.36	5.62	3.82	1.96	0
220	16.00	15.42	14.70	14.00	13.19	12.33	11.64	10.84	9.20	7.50	5.73	3.93	1.98
240	17.79	17.13	16.42	15.69	14.96	14.20	13.43	12.65	11.05	9.37	7.64	5.90	3.97
260	19.40	18.85	18.15	17.44	16.71	15.97	15.22	14.45	11.88	11.24	9.56	7.86	5.96
280	21.10	20.56	19.87	19.18	18.47	17.75	17.01	16.26	14.72	13.02	11.46	9.73	7.94
300	22.88	22.27	21.61	20 92	20.23	19.52	18.81	18.07	16.49	14.99	13.37	11.70	9.93

Babcock & Wilcox's Patent Fuel Economizer is provided for this purpose. It consists of a series of vertical tubes placed in a brick chamber which forms part of the flue between the boiler and the chimney, and through which all the hot gases are caused to pass. These tubes are connected at top and bottom with horizontal tubes, the lower row of which are connected to a mud-drum, and the upper row are connected together at the end diagonally opposite to the mud-drum. The feed-water enters at one end of the mud-drum and passes out at the opposite end of the upper connecting pipe. It will be seen that the water has the same distance to go, and the same resistance to encounter in whichever of the vertical pipes it may travel, and that therefore it will flow fastest where its gravity is least, or directly as its temperature, and only the hottest portion will be discharged. The hotter gases, filling the upper portion of the chamber, come in contact with the water at its highest temperature, so that it is possible to heat the latter very nearly to the temperature of the escaping gases before it flows to the boiler.

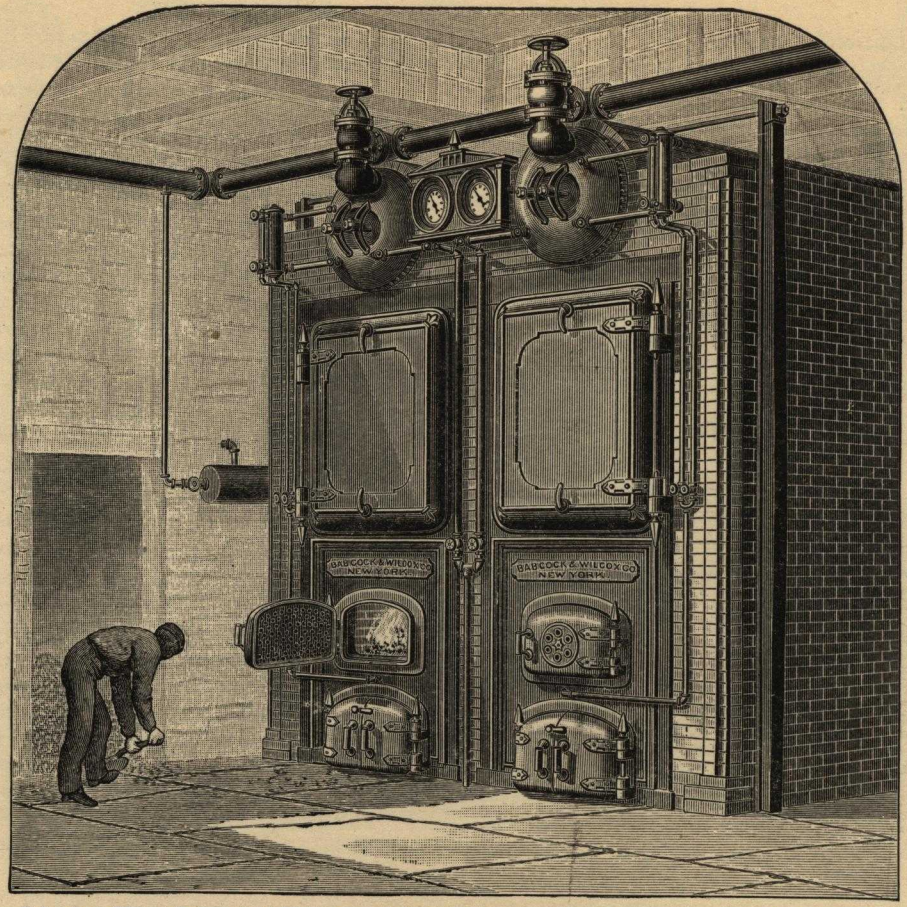
Ample provision is made for cleaning the interior of the vertical and horizontal tubes, and the mud-drums by means of hand-holes with metallic joints opposite the ends of each tube. This is important as in most hard waters sediment will form in the economizer more readily than in the boiler.

By means of a direct flue to chimney, the economizer may be cleaned without stopping the boilers.

Mechanical scrapers worked from above are provided for removing deposits of soot from the exterior of the tubes, the soot falling into a chamber below, from which it may be removed at convenience.

All joints in the construction of the economizer **are metallic**, no packing of any kind being used, except for the large hand-holes in the mud-drum, and the parts are so put together that **any one part may be removed and replaced** without disturbing the other parts, and with comparatively little trouble. The tubes are made of cast iron, the experience of years having proven that this is much the best material to resist the tendency to corrosion arising from the condensation of vapors upon their exterior. Wrought iron has been found utterly unsuited to the purpose.

The Babcock & Wilcox Fuel Economizer is an improvement upon those which have been largely used in England, in the mechanical construction and in convenience of access and repair. It is confidently presented to the public as the very best thing of the kind at present known.



Babcock & Wilcox Boilers, 164 H. P., erected 1884 for E. Greenfield & Co., Confectioners, Brooklyn, N. Y.

INCRUSTATION AND SCALE.

Nearly all waters contain foreign substances in greater or less degree, and though this may be a small amount in each gallon, it becomes of importance where large quantities are evaporated. For instance, a 100 H. P. boiler evaporates 30,000 lbs. water in ten hours, or 390 *tons* per month; in the comparatively pure Croton water there would be 88 pounds of solid matter in that quantity, and in many kinds of spring water as much as 2,000 lbs.

The nature and hardness of the scale formed of this matter will depend upon the kind of substances held in solution and suspension. Analysis of a great variety of incrustations show that carbonate and sulphate of lime form the larger part of all ordinary scale, that from carbonate being soft and granular, and that from sulphate hard and crystalline. Organic substances in connection with carbonate of lime, will also make a hard and troublesome scale.

The presence of scale or sediment in a boiler results in loss of fuel, burning and cracking of the boiler, predisposes to explosion, and leads to extensive repairs. It is estimated that the presence of $\frac{1}{16}$ inch of scale causes a loss of 13 per cent. of fuel, $\frac{1}{8}$ inch 38 per cent., and $\frac{1}{4}$ inch 60 per cent. The Railway Master Mechanics' Association of the U. S. estimates that the loss of fuel, extra repairs, etc., due to incrustation, amount to an average of $750 per annum for every locomotive in the middle and western States, and it must be nearly the same for the same power in stationary boilers.

MEANS OF PREVENTION.

It is absolutely essential to the successful use of any boiler, except in pure water, that it be accessible for the removal of scale, for though a rapid circulation of water will delay the deposit, and certain chemicals will change its character, yet the most certain cure is **periodical inspection and mechanical cleaning.** Very bad water may, however, be rendered practically pure by the use of live steam purifiers, as made by the Babcock & Wilcox Co., in which all the solid matters are taken out of the water before it reaches the boilers. Its action is based on the fact that the salts which form scale are more soluble in cold than in hot water, and at a high temperature they are caused to deposit.

The following notes in regard to various chemicals may be useful:—

M. Bidard's observations show that "anti-incrustators" containing organic matter help rather than hinder incrustations, and are therefore to be avoided.

Oak, hemlock, and other barks and woods, sumac, catechu, logwood, etc., are effective in waters containing carbonates of lime or magnesia, by reason of their tannic acid, but are injurious to the iron, and not to be recommended.

Molasses, cane juice, vinegar, fruits, distillery slops, etc., have been used with success so far as scale is concerned, by reason of the acetic acid which they contain, but this is even more injurious to the iron than tannic acid, while the organic matter forms a scale with sulphate of lime when it is present.

Milk of lime and metallic zinc have been used with success in waters charged with bicarbonate of lime, reducing the bicarbonate to the insoluble carbonate.

Barium chloride and milk of lime are said to be used with good effect at Krupp's Works, in Prussia, for waters impregnated with gypsum.

Soda ash and other alkalies are very useful in waters containing sulphate of lime, by converting it into a carbonate, and so forming a soft scale easily cleaned. But when used in excess they cause foaming, particularly where there is oil coming from the engine, with which they form soap. All soapy substances are objectionable for the same reason.

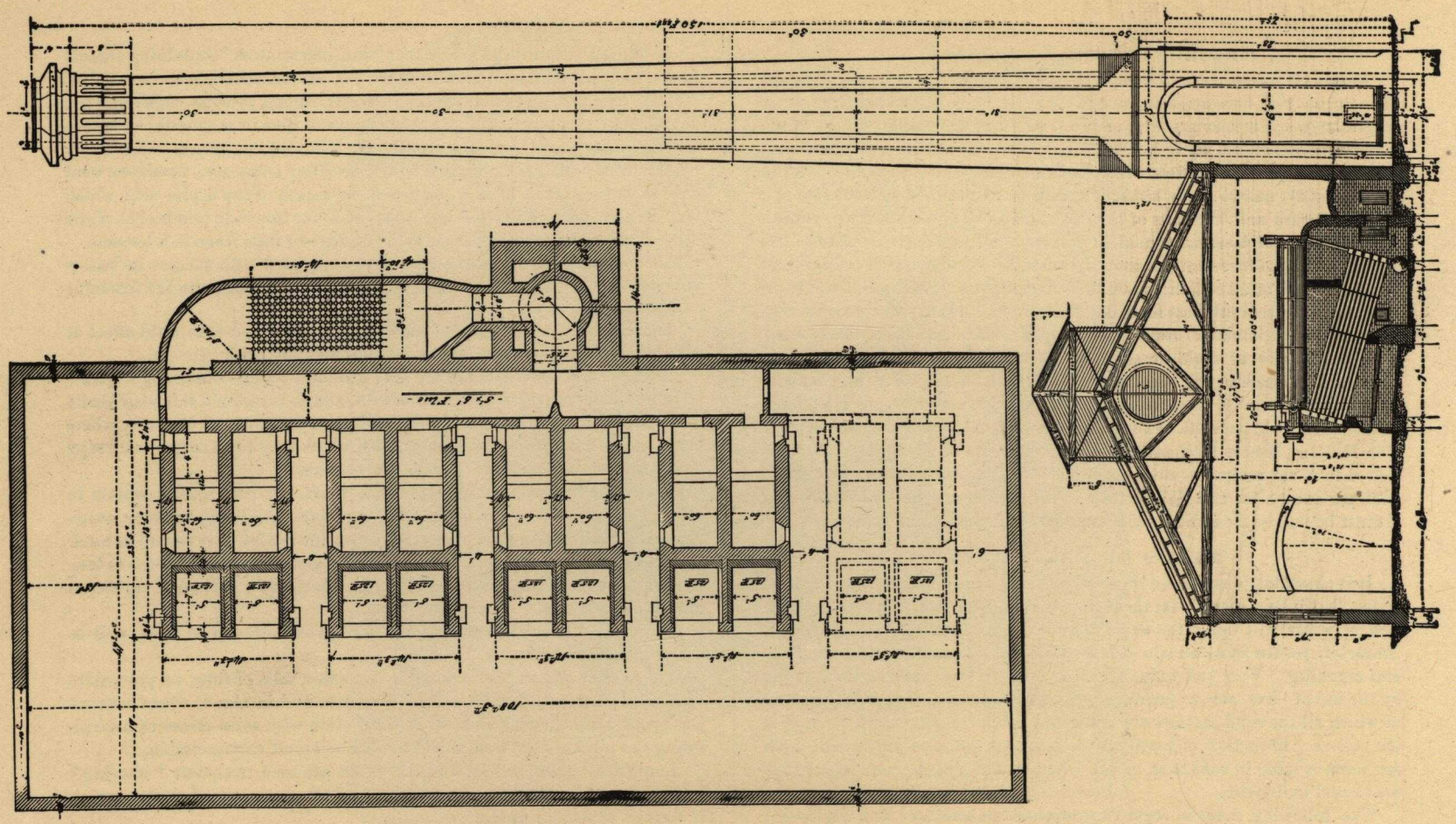
Petroleum has been much used of late years. It acts best in waters in which sulphate of lime predominates. As crude petroleum, however, sometimes helps in forming a very injurious crust, the refined only should be used.

Tannate of soda is a good preparation for general use, but in waters containing much sulphate, it should be supplemented by a portion of carbonate of soda or soda ash.

A decoction from the leaves of the eucalyptus is found to work well in some waters, in California.

For muddy water, particularly if it contain salts of lime, no preventive of incrustation will prevail except filtration, and in almost every instance the use of a filter, either alone or in connection with some means of precipitating the solid matter from solution, will be found very desirable.

In all cases where impure or hard waters are used, frequent "blowing" from the mud-drum is necessary to carry off the accumulated matter, which if allowed to remain would form scale.



1000 H. P. Babcock & Wilcox Boilers—Boiler House and Stack—at W. C. Hamilton & Sons' Paper Mill, Philadelphia Pa.

CHIMNEYS.

Chimneys are required for two purposes—1st, to carry off obnoxious gases, 2d, to produce a draught, and so facilitate combustion. The first requires **size,** the second **height.**

Each pound of coal burned yields from 13 to 30 pounds of gas, the volume of which varies with the temperature.

The weight of gas carried off by a chimney in a given time depends upon three things—size of chimney, velocity of flow, and density of gas. But as the density decreases directly as the absolute temperature, while the velocity increases, with a given height, nearly as the square root of the temperature, it follows that there is a temperature at which the weight of gas delivered is a maximum. This is about 550° above the surrounding air. Temperature, however, makes so little difference, that at 550° above, the quantity is *only four per cent.* greater than at 300°. Therefore, height and area are the only elements necessary to consider in an ordinary chimney.

The **intensity of draught** is, however, independent of the size, and depends upon the difference in weight of the outside and inside columns of air, which varies directly with the product of the height into the difference of temperature. This is usually stated in an equivalent column of water, and may vary from 0 to possibly 2 inches.

To find the maximum draft for any given chimney, the heated column being 612° F., and the external air 62°:— *Multiply the height above grate in feet by* **.0075,** *and the product is the draft power in inches of water.*

The intensity of **draft required** varies with the kind and condition of the fuel, and the thickness of the fires. Wood requires the least, and fine coal or slack the most. To burn anthracite slack to advantage, a draught of 1¼ inch of water is necessary, which can be attained by a well-proportioned chimney 175 ft. high.

A **round chimney** is better than square, and a straight flue better than tapering, though it may be either larger or smaller at top without detriment.

The effective **area of a chimney** for a given power, varies inversely as the square root of the height. The actual area, in practice, should be greater, because of retardation of velocity due to friction against the walls. On the basis that this is equal to a layer of air two inches thick over the whole interior surface, and that a commercial horse-power requires the consumption of an average of 5 pounds of coal per hour, we have the following formulæ:

$$E = \frac{0.3\,H}{\sqrt{h}} = A - 0.6\sqrt{A} \quad \ldots\ldots 1$$

$$H = 3.33\,E\sqrt{h} \quad \ldots\ldots 2$$

$$S = 12\sqrt{E} + 4 \quad \ldots\ldots 3$$

$$D = 13.54\sqrt{E} + 4 \quad \ldots\ldots 4$$

$$h = \left(\frac{0.3\,H}{E}\right)^2 \quad \ldots\ldots 5$$

In which H = horse-power; h = height of chimney in feet; E = effective area, and A = actual area in square feet; S = side of square chimney, and D = dia. of round chimney in inches. The following table is calculated by means of these formulæ, by Wm. Kent:—

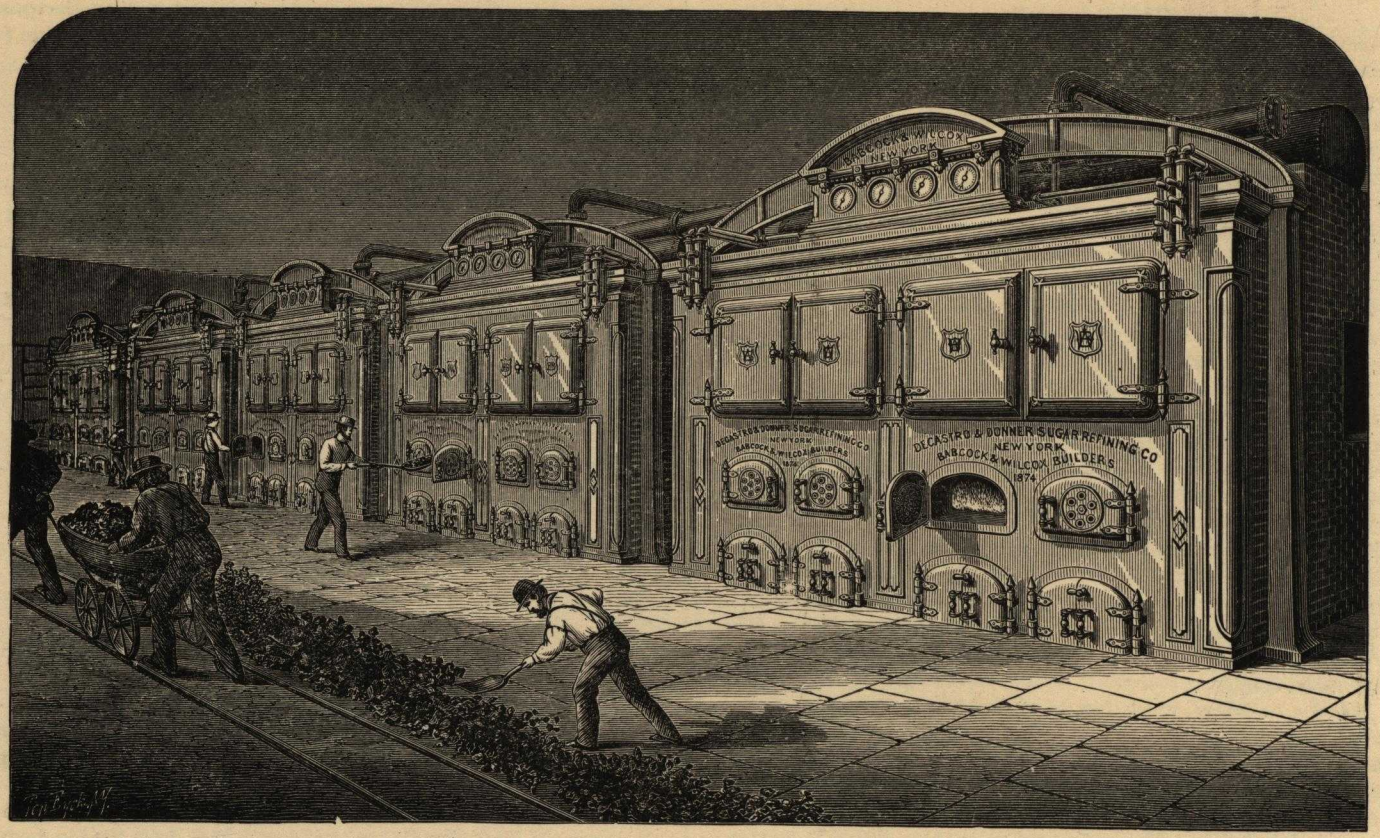
SIZES OF CHIMNEYS WITH APPROPRIATE HORSE-POWER OF BOILERS.

Dia. in inches.	Height of Chimneys, and Commercial Horse-Power.											Side of square inches.	Effective Area. square ft.	Actual Area. square ft.
	50 ft	60 ft	70 ft	80 ft.	90 ft.	100 ft	110 ft.	125 ft.	150 ft.	175 ft.	200 ft.			
18	23	25	27									16	0.97	1.77
21	35	38	41									19	1.47	2.41
24	49	54	58	62								22	2.08	3 14
27	65	72	78	83								24	2.78	3.98
30	84	92	100	107	113							27	3.58	4.91
33		115	125	133	141							30	4.48	5.94
36		141	152	163	173	182						32	5.47	7 07
39			183	196	208	219						35	6.57	8 30
42			216	231	245	258	271					38	7.76	9 62
48				311	330	348	365	389				43	10.44	12.57
54					427	449	472	503	551			48	13.51	15.90
60					536	565	593	632	692	748		54	16.98	19.64
66						694	728	776	849	918	981	59	20.83	23.76
72						835	876	934	1023	1105	1181	64	25.08	28.27
78							1038	1107	1212	1310	1400	70	29.73	33.18
84							1214	1294	1418	1531	1637	75	34.76	38.48
90								1496	1639	1770	1893	80	40.19	44.18
96									1876	2027	2167	86	46.01	50.27

The **external diameter** at the base should be one-tenth the height, unless it be supported by some other structure. The **"batter" or taper** of a chimney should be from $\frac{3}{16}$ to ¼ inch to the foot on each side.

Thickness of brick work: one brick (8 or 9 inches) for 25 ft. from the top, increasing ½ brick (4 or 4½ inches) for each 25 ft. from the top downwards.

If the inside diameter exceed 5 ft. the top length should be 1½ bricks, and if under 3 ft. it may be ½ brick for ten feet.



1500 H. P. Babcock & Wilcox Boilers at DeCastro & Donner's Sugar Refining Co's Refinery, foot of North 3d St., Brooklyn, E. D. 1200 H. P. erected 1874; 300 H. P. erected 1876.

HEATING BY STEAM.

In heating buildings by steam the amount of boiler and heating pipe depends largely on the kind of building and its location. Wooden buildings require more than stone, and stone more than brick. Iron fronts require still more, and glass in windows demands twenty times as much heat as the same surface in brick walls. Also if the heating be done by indirect radiation from 50 to 100 per cent. more will be required than when direct radiation is used. No rules can be given which will not require a liberal application of "the coëfficient of common sense."

Radiating Surface may be calculated by the rule :— *Add together the square feet of glass in the windows, the number of cubic feet of air required to be changed per minute, and one twentieth the surface of external wall and roof; multiply this sum by the difference between the required temperature of the room and that of the external air at its lowest point, and divide the product by the difference in temperature between the steam in the pipes and the required temperature of the room.* The quotient is the required radiating surface in square feet. Each square foot of radiating surface may be depended upon in average practice to give out three heat units per hour for each degree of difference in temperature between the steam inside and the air outside, the range under different conditions being about 50 per cent. above or below that figure. In *indirect* heating, the efficiency of the radiating surface will increase, and the temperature of the air will diminish, when the quantity of air caused to pass through the coil increases. Thus one square foot radiating surface, with steam at 212, has been found to heat 100 cubic feet of air per hour from zero to 150°, or 300 cubic feet from zero to 100° in the same time.

The best results are attained by using indirect radiation to supply the necessary ventilation, and direct radiation for the balance of the heat. The best place for a radiator in a room is beneath a window. Heated air cannot be made to enter a room unless means are provided for permitting an equal amount to escape. The best place for such exit openings is near the floor.

Small pipes are more effective than large. When the diameter is doubled, 20 per cent. additional surface should be allowed, and for three times the diameter, 30 per cent. additional is required. For indirect radiation that surface is most efficient which secures the most intimate contact of the current of air with the heated surface. Rooms on windward side of house require more radiating surface than those on sheltered side.

Where the condensed water is returned to the boiler, or where low pressure of steam is used, the **Diameter of Mains** leading from the boiler to the radiating surface should be equal, in inches, to *one-tenth the square root of the radiating surface, mains included,* in square feet. Thus a 1-inch pipe will supply 100 square feet of surface, itself included. **Return pipes** should be at least ¾ inches in diameter, and never less than one-half the diameter of the main,—longer returns requiring larger pipe. A thorough drainage of steam pipes will effectually prevent all cracking and pounding noises therein.

The **Amount of Air** required for ventilation is from 4 to 16 cubic feet per minute for each person, the larger amount being for prisons and hospitals. From ½ to 1 cubic foot per minute should also be allowed for each lamp or gas burner employed.

One square foot of **Boiler Surface** will supply from 7 to 10 square feet of radiating surface, depending upon the size of boiler and the efficiency of its surface, as well as that of the radiating surface. Small boilers for house use should be much larger proportionately than large plants. Each **Horse-power of Boiler** will supply from 240 to 360 feet of 1-in. steampipe, or 80 to 120 square feet of radiating surface.

Cubic feet of Space has little to do with amount of steam or surface required, but is a convenient factor for rough calculations. Under ordinary conditions **one horse-power will heat**, approximately, in

Brick dwellings, in blocks, as in cities . .	15,000 to 20,000 cub. ft.
" stores " "	10,000 " 15,000 " "
" dwellings, exposed all around . .	10,000 " 15,000 " "
" mills, shops, factories, &c. . .	7,000 " 10,000 " "
Wooden dwellings, exposed	7,000 " 10,000 " "
Foundries and wooden shops . . .	6,000 " 10,000 " "
Exhibition buildings, largely glass, &c. . .	4,000 " 15,000 " "

The system of heating mills and manufactories by means of pipes placed overhead, is being largely adopted, and is recommended by the Boston

Babcock & Wilcox Boilers, at De Castro & Donner Sugar Refining Co's Refinery, foot of South 9th St., Brooklyn, E. D., N. Y. Erected 1871. 1st and 2d Orders. 900 H. P.
Facing these have been added 150 H. P. 1877; 300 H. P. 1881; Total, 1350 H. P.

Manufacturers' Mutual Fire Ins. Co. in preference to radiators near the floor, particularly for rooms in which there are shafting and belting to circulate the air.

A much needed attachment has recently been introduced, which acts automatically upon the steam valves of the radiators, or upon the hot air registers and ventilators, and maintains the temperature in a room to within one-half a degree of any standard desired.

A "separator" acting by centrifugal force has been recently tested, and is very efficient, in trapping out all the water entrained in steam. It will be found valuable, particularly where the steam has to be carried a long distance from the boiler, and for the purpose of preventing "hammering" of water in the pipes.

HEATING LIQUIDS AND BOILING BY STEAM.

(*a*). **Efficiency of surface,** where all the air is expelled. For vertical surface, each square foot will transmit 230 heat units per hour, for each degree of difference in the temperature of the two sides. For horizontal and inclined surface, each square foot will transmit 330 heat units per hour for each degree of difference in temperature between the two sides.

(*b*.) **Steam required.** Each 966 heat units will require the condensation of one pound of steam at 212°, or 1,000 units at 75 lbs. pressure. Each pound of steam condensed will evaporate one pound of water (nearly) from the temperature of evaporation. Each horse-power of boiler will heat 30,000 lbs. water 1° per hour, or evaporate 30 lbs. water in the same time.

DRYING BY STEAM.

There are **three modes** of drying by steam. 1st. By bringing wet substances in direct contact with steam-heated surfaces, as by passing cloth or paper over steam-heated cylinders, or clamping veneers between steam-heated plates. 2d. By radiated heat from steam pipes, as in some lumber kilns, and laundry drying rooms. 3d. By causing steam-heated air to pass over wet surfaces, as in glue works, &c.

The second is rarely used except in combination with the third. The first is the most economical, the second less so, and the third least. Under favorable circumstances, it may be estimated that **one horse-power of steam** will evaporate 24 lbs. water by the first method, 20 by the second, and 15 by the third.

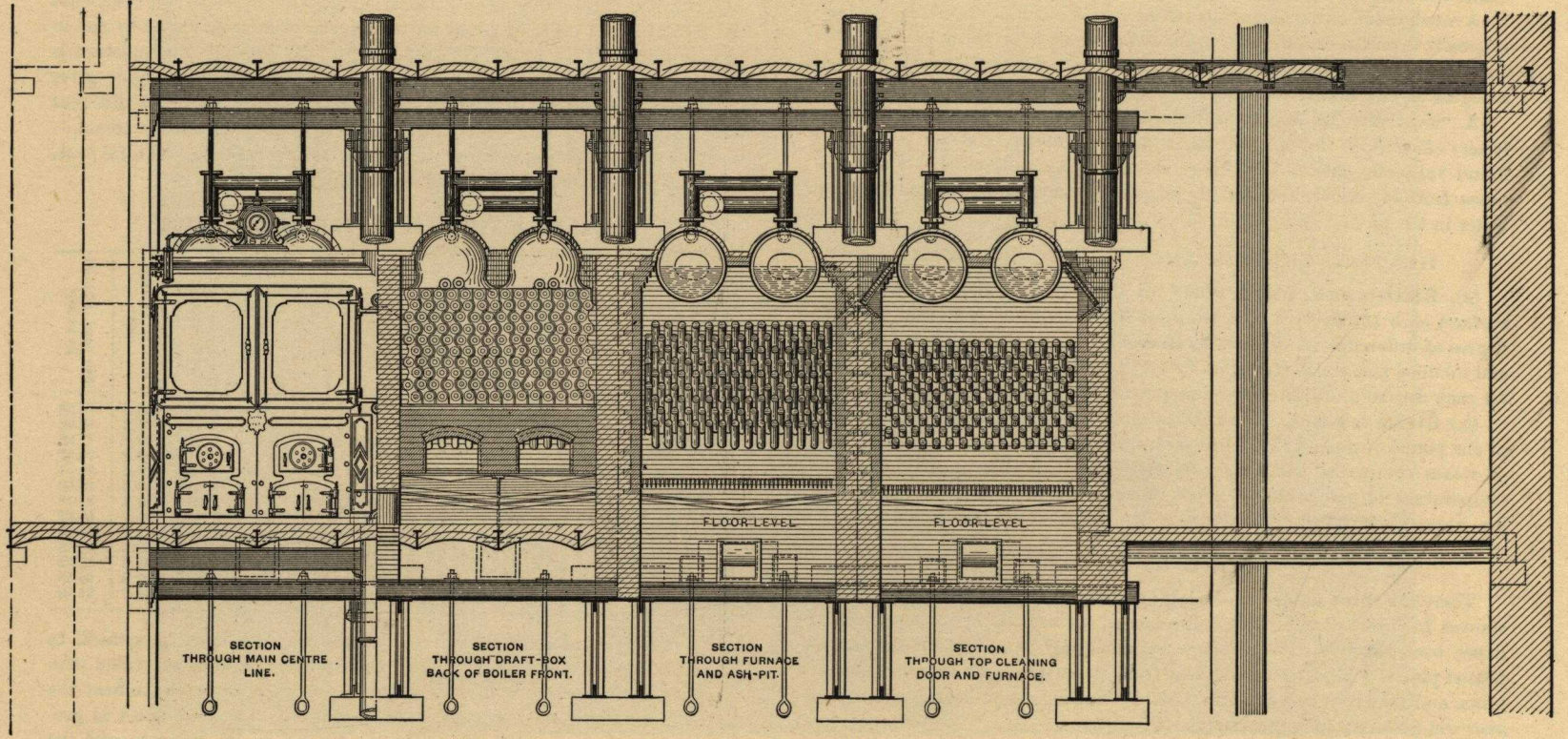
The philosophy of drying or evaporating moisture by heated air rests upon the fact that the capacity of air for moisture is rapidly increased by rise in temperature. If air at 52° is heated to 72°, its capacity for moisture is doubled, and is four times what it was at 32°. The following table gives the weight of a saturated mixture of air and aqueous vapor at different temperatures up to 160°—the practical limit of heating air by steam,—together with the weight of vapor, in pounds and per centage, and total heat, with the portion thereof contained in the vapor:—

SATURATED MIXTURES OF AIR AND AQUEOUS VAPOR.

Temperature, degrees Fah.	Weight of 100 cub. ft. of mixture in lbs.	Weight of water in 100 cub. ft. of mixture in lbs.	Per cent. of water in mixture.	Heat Units in 100 cub. ft. of mixture.	Per cent. of heat in vapor.	Temperature, degrees Fah.	Weight of 100 cub. ft. of mixture in lbs.	Weight of water in 100 cub. ft. of mixture, in lbs.	Per cent. of water in mixture.	Heat Units in 100 cub. ft. of mixture.	Per cent. of heat in vapor.
35	8.004	0.034	0.42	42.8	86.69	100	6.924	0.283	4.08	422.0	74.58
40	7.920	0.041	0.52	59.8	76.59	105	6.830	0.325	4.76	474.7	76.22
45	7.834	0.049	0.62	77.7	68.98	110	6.741	0.373	5.23	533.9	77.88
50	7.752	0.059	0.76	97.6	66.29	115	6.650	0.426	6.41	599.1	79.52
55	7.688	0.070	0.91	118 3	64.58	120	6.551	0.488	7.46	672.4	81.14
60	7.589	0.082	1.08	140.1	64.31	125	6.454	0.554	8.55	750.5	82.62
65	7.507	0.097	1.29	164.9	64.76	130	6.347	0.630	9.90	839.4	84.13
70	7.425	0.114	1.49	189.7	66.21	135	6.238	0.714	11.44	936.7	85.57
75	7.342	0.134	1.79	221.6	66 74	140	6.131	0.806	13.14	1042.7	86.89
80	7.262	0.156	2.15	253.6	68.02	145	6.015	0.909	15.11	1160.6	88 18
85	7.178	0.182	2.54	289.7	69.66	150	5.891	1.022	17.33	1288.4	89.39
90	7.108	0.212	2.98	330.2	71.19	155	5.764	1.145	19.88	1427.4	90.53
95	7.009	0.245	3.50	373.4	72.87	160	5.679	1.333	23.47	1638.7	91.93

By inspection of above table it will be seen why it is more economical to dry at the higher temperatures. The atmosphere is seldom saturated with moisture, and in practice it will be found generally necessary to heat the air about 30° above the temperature of saturation. The best effect is produced where there is artificial ventilation, by fan or by chimney, and the course of the heated air is from above downwards.

NEW YORK STEAM COMPANY, STATION B. GREENWICH STREET, NEW YORK.


FLOOR LEVEL
FLOOR LEVEL
SECTION THROUGH MAIN CENTRE LINE.
SECTION THROUGH DRAFT-BOX BACK OF BOILER FRONT.
SECTION THROUGH FURNACE AND ASH-PIT.
SECTION THROUGH TOP CLEANING DOOR AND FURNACE.

Front Elevation, showing Battery of four Boilers, 250 H. P. each.

When complete, the Station will contain 64 Boilers, or 16000 H. P., in all.
12000 Horse Power in operation.

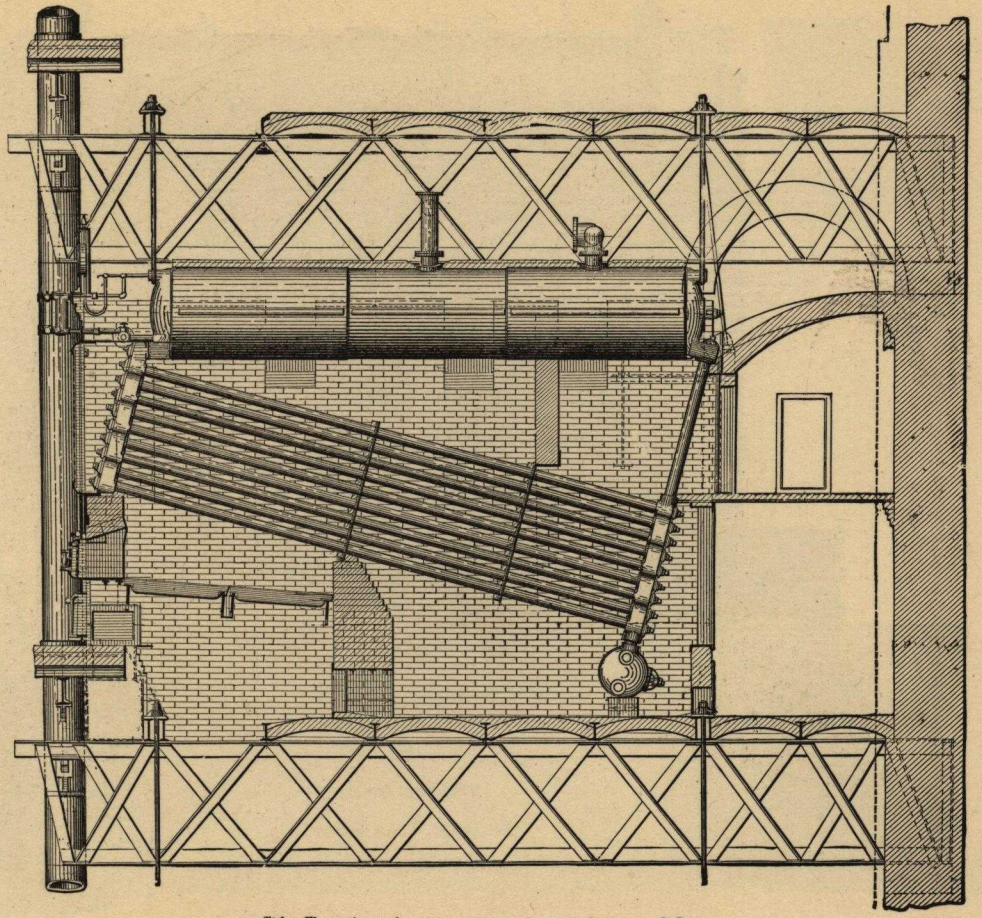
BOILERS OF THE NEW YORK STEAM CO.

[From the *Mechanical News*, Nov. 1, 1882.]

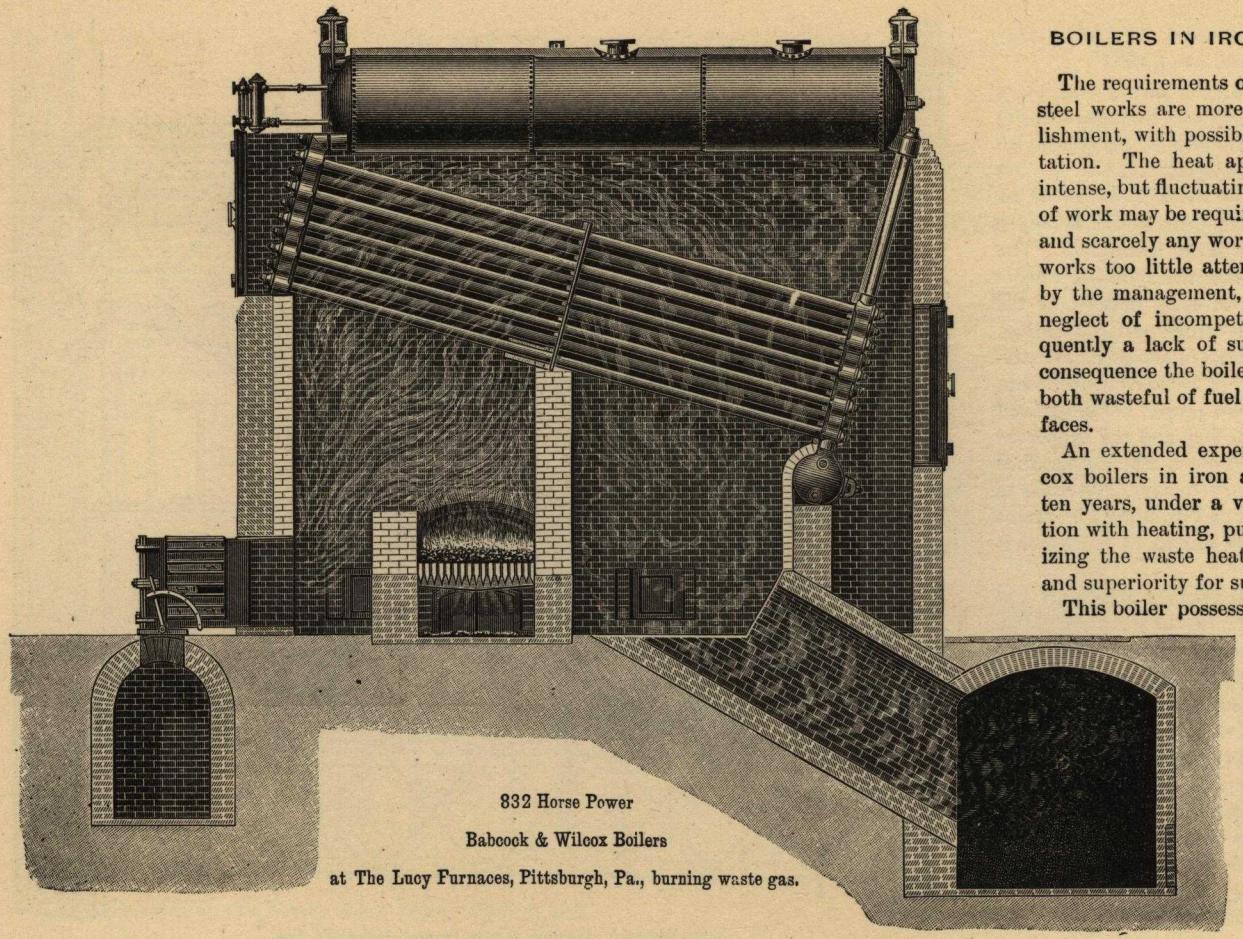
In our issue of August 1, we gave partial description and illustrations of the plant which the New York Steam Company are putting down at Station B, on Greenwich Street, near Cortlandt. In the present number we are enabled to publish details, showing the construction of the boilers and the method of setting them in the house, as well as the constructions of the floors themselves. The longitudinal section previously published shows four floors with two batteries of boilers upon each, divided by the stack, which runs up through the center of the building. The present drawings are the details of one of these batteries, which consists of four boilers of 250 horse-power each.

It will be seen that the boilers proper are suspended from the floor-beams of the building, and are supported entirely independent of the brick-work which surrounds them, thus enabling any necessary repairs to be made to one without disturbing the other, and avoiding the strains which necessarily arise when the weight of the boiler is carried by its setting.

In a work of this magnitude it becomes absolutely imperative that the boilers which furnish the steam should be of such a construction as to give the greatest amount of useful effect for the coal burnt, and at the same time be able to run continuously, with a minimum amount of stoppage for repairs; and, above all, they should be so constructed as to be safe against destructive explosion. The ability to furnish dry steam is also a very important point, where it is intended to carry it through so many miles of pipe before it is final y used up. The boiler adopted was decided to be the one which came nearest to filling all these requirements. As will be seen by the engravings, it is wnat is known as the Babcock & Wilcox Water-tube Boiler.



Side Elevation, showing section through boiler and flue.



832 Horse Power

Babcock & Wilcox Boilers

at The Lucy Furnaces, Pittsburgh, Pa., burning waste gas.

BOILERS IN IRON AND STEEL WORKS.

The requirements of a steam boiler in an iron or steel works are more severe than in any other establishment, with possibly the exception of a sugar plantation. The heat applied to the boiler is not only intense, but fluctuating. The utmost possible amount of work may be required from the boiler for one hour, and scarcely any work the next, while in many iron works too little attention is paid to the boiler-house by the management, and they are left to the care or neglect of incompetent men. There is, also, frequently a lack of sufficient boiler capacity, and in consequence the boilers are driven at a rate which is both wasteful of fuel and destructive to heating surfaces.

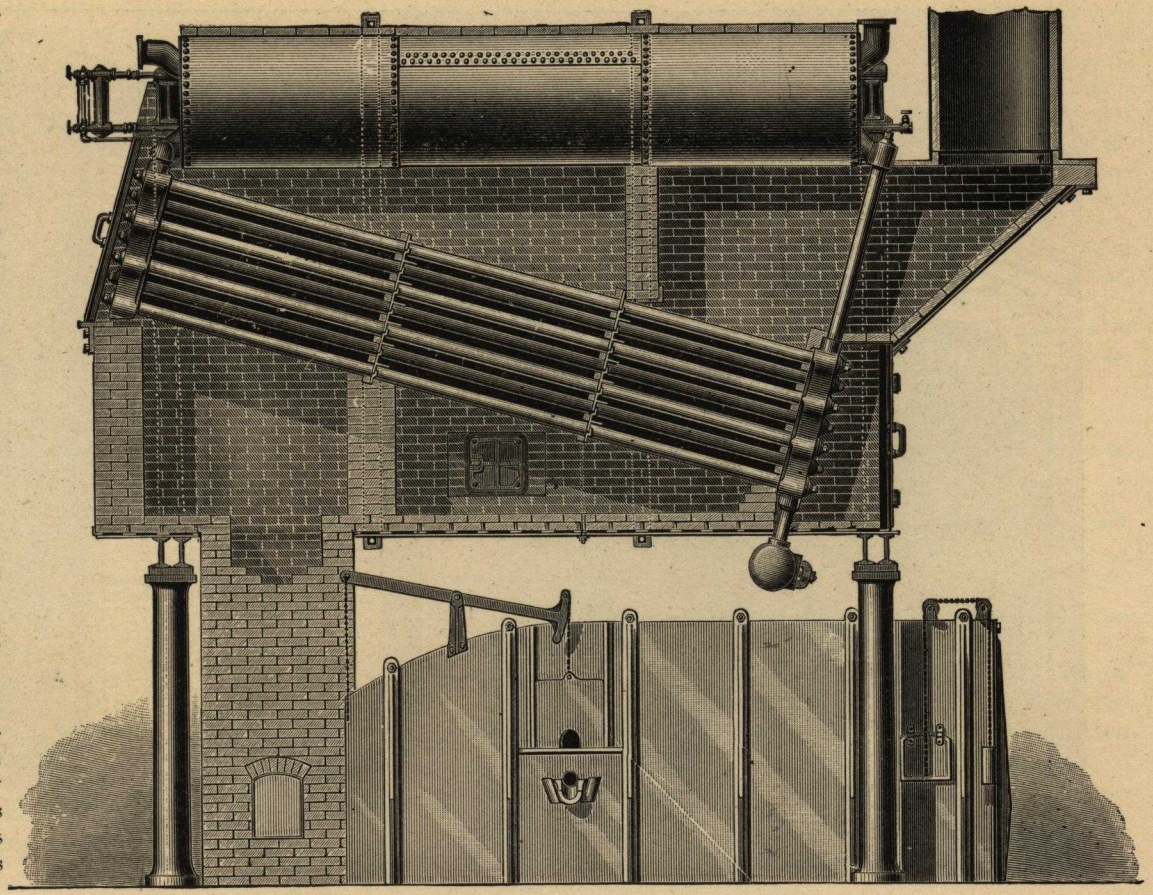
An extended experience with the Babcock & Wilcox boilers in iron and steel works extending over ten years, under a variety of conditions, in connection with heating, puddling and blast furnaces, utilizing the waste heat, has shown their adaptability and superiority for such work.

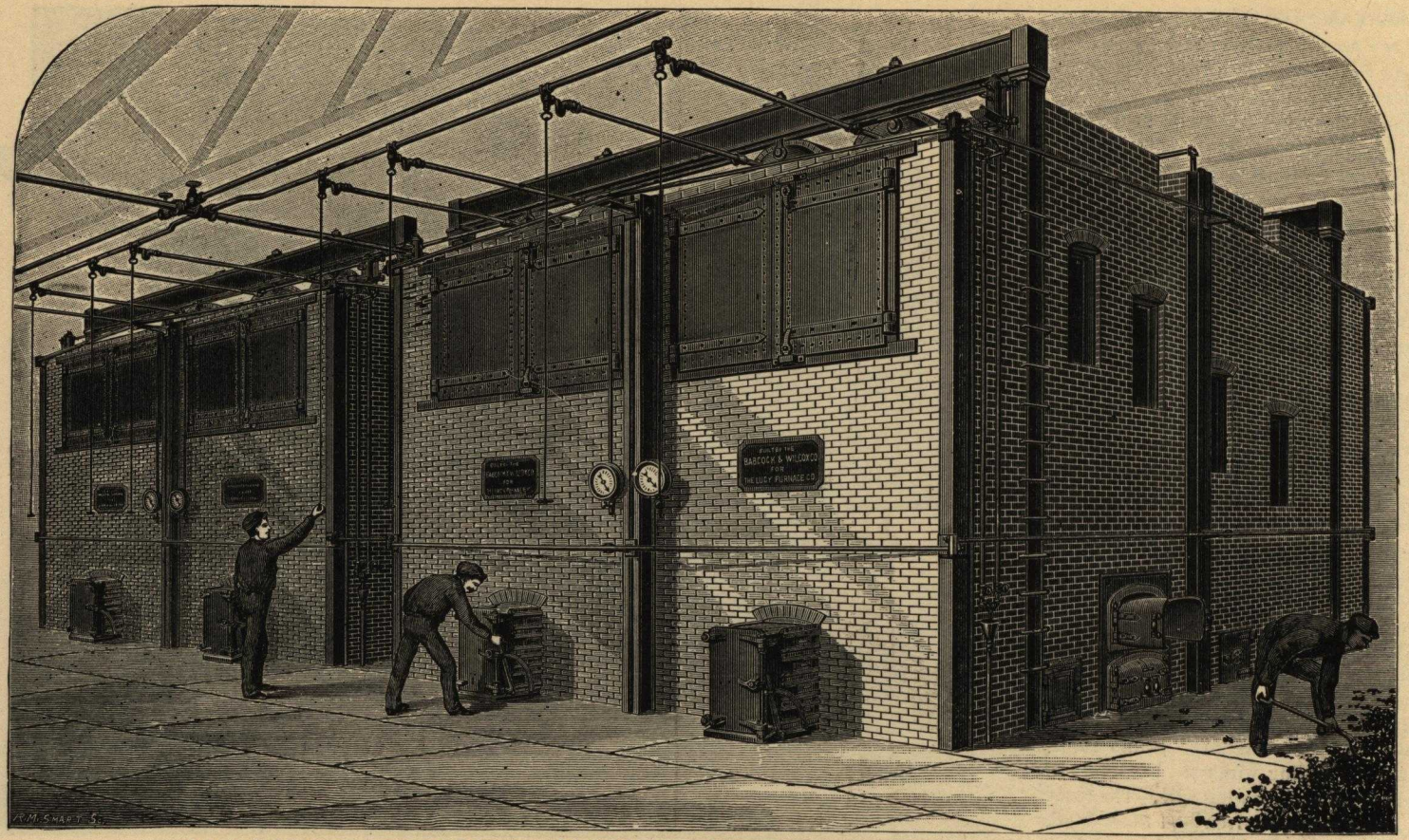
This boiler possesses for this purpose the advantages of safety and economy. The intense heat of the gases from a puddling furnace is very destructive of thick plates and riveted joints, causing frequent violent explosions in boilers so heated. The thin tubes, and rapid circulation, in these boilers render them less liable to damage from the high tem

perature, and the arrangement of heating surface secures a fuller absorption of the waste heat. Should a tube burn out, no serious explosion can occur.

Some establishments place their boilers over the furnaces, as shown in the cut, while others place them at the side of the furnace, or in the rear. One advantage for this boiler, especially for double puddling and large heating furnaces, is that a much larger amount of heating surface can be placed over a furnace than can be done with the boilers ordinarily used for this purpose, thereby giving greater economy of fuel with less cost of erection. At The Carron Iron Works, near Glasgow, Scotland, the Lucy Furnaces, Pittsburgh, Pa., and elsewhere, these boilers are fired with the waste gases of the blast furnaces with marked success. The combustion of the gas is perfect; the boilers develop much more than their rated capacity, and the dust contained in the gas has given no trouble.

In rolling mills doing the heaviest and most irregular kind of work, the success of these boilers has been equally encouraging, and, in a number of the Bessemer Steel Works, they are supplying steam to reversing engines rolling steel ingots in two high trains, while several large plants supply power for rolling wire rods, bar iron, rails and beams, and drawing wire. The names of many extensive Iron and Steel Works will be found in the list of references.





Babcock & Wilcox Boilers, 832 H. P., at Lucy Furnace, Pittsburgh, Pa. Erected 1883. Fired with waste gases from blast furnaces.

FLOW OF STEAM THROUGH PIPES.

The quantity of steam flowing through a pipe in a given time under a given "head" or loss of pressure, increases more rapidly than the area of the pipe, or its ratio to the length, directly as the square root of the density, and of the loss of pressure, and inversely as the square root of the length.

The following table gives approximately, the **weight of steam per minute** which will flow from various initial pressures, with a loss of pressure due to friction of one pound per square inch, through different sizes of straight smooth pipes, each having a length of 240 times its own diameter, (equal to 20 feet for each inch in diameter). It has been calculated by the formula:

$$W = 303.25\ d^2 \sqrt{\frac{D\,(p_1 - p_2)}{L\left(1 + \frac{3.6}{d}\right)}}$$

In which d = diameter in inches, D = density or weight per cubic foot; p_1 the initial pressure, p_2 the pressure at end of pipe, and L = the length *expressed in diameters.* For sizes of pipe below 6 inch, the flow is calculated from the *actual* areas of "standard" pipe of such nominal diameters.

TABLE OF FLOW OF STEAM THROUGH PIPES.

Initial pressure by gauge, lbs. per sq. in.	Diameter of Pipe in Inches. Length of each = 240 diameters.													
	¾	1	1½	2	2½	3	4	5	6	8	10	12	15	18
	Weight of Steam per minute in pounds, with 1 pound loss of pressure.													
1	1.16	2.07	5.7	10.27	15.45	25.38	46.85	77.3	115.9	211 4	341.1	502.4	804	1177
10	1.44	2.57	7.1	12.72	19.15	31.45	58.05	95.8	143.6	262 0	422.7	622.5	996	1458
20	1.70	3.02	8.3	14.94	22.49	36.94	68.20	112.6	168.7	307 8	496.5	731.3	1170	1713
30	1.91	3.40	9.4	16.84	25.35	41.63	76.84	126.9	190.1	346.8	559.5	824.1	1318	1930
40	2.10	3.74	10.3	18.51	27.87	45.77	84.49	139.5	209.0	381.3	615.3	906.0	1450	2122
50	2.27	4.04	11.2	20.01	30.13	49.48	91.34	150.8	226.0	412 2	665.0	979.5	1567	2294
60	2.43	4.32	11.9	21.38	32.19	52.87	97.60	161.1	241.5	440.5	710.6	1046.7	1675	2451
70	2.57	4.58	12.6	22.65	34.10	56.00	103.37	170.7	255.8	466.5	752.7	1108.5	1774	2596
80	2.71	4.82	13.3	23.82	35.87	58.91	108.74	179.5	269.0	490 7	791.7	1166.1	1866	2731
90	2.83	5.04	13.9	24.92	37.52	61.62	113.74	187.8	281.4	513.3	828.1	1219.8	1951	2856
100	2.95	5.25	14.5	25.96	39.07	64.18	118.47	195.6	293.1	534.6	862.6	1270.1	2032	2975
120	3.16	5.63	15.5	27.85	41.93	68.87	127.12	209.9	314.5	573.7	925.6	1363.3	2181	3193
150	3.45	6.14	17.0	30.37	45.72	75.09	138.61	228.8	343.0	625.5	1009.2	1486.5	2378	3481

For **horse power,** multiply the figures in the table by 2. For any other loss of pressure, multiply by the square root of the given loss. For any other length of pipe, *divide* 240 *by the given length expressed in diameters, and multiply the figures in the table by the square root of this quotient,* which will give the flow for 1 lb. loss of pressure. Conversely, dividing the given length by 240 will give the loss of pressure for the flow given in the table.

The **resistance to the steam entering the pipe,** when it is not provided with special bell mouth opening, is equal to the friction of 60 diameters additional length, or 25 per cent. additional loss of pressure under the conditions of the table. A **globe valve** may be estimated as 60, and each **elbow** as 40 diameters additional length. Thus, a pipe 120 diameters in length, with one globe valve and three elbows, would have 1½ lbs. loss of pressure with the flow given in the table, or deliver $1 \div \sqrt{1\frac{1}{2}} = 81.7$ per cent. of the steam, with one pound loss of pressure. These equivalents, viz:— 60 for opening, 60 for each globe valve, and 40 for each elbow must be added in all cases in estimating the length of pipe; thus in the case just given. $120 + 60 + 60 + (3 \times 40) = 360 = 240 \times 1\frac{1}{2}$.

FLOW OF STEAM FROM A GIVEN ORIFICE.

1. Where the steam escapes into a pressure less than half that in the boiler:—

$H = \frac{(p+15) \times 12\,a\,k}{7}$; where H = horse-power, p = pressure of steam by guage, a = area of orifice in square inches, and k is a co-efficient = .93 for a short cylindrical pipe, or .63 for a thin opening, or for a safety valve.

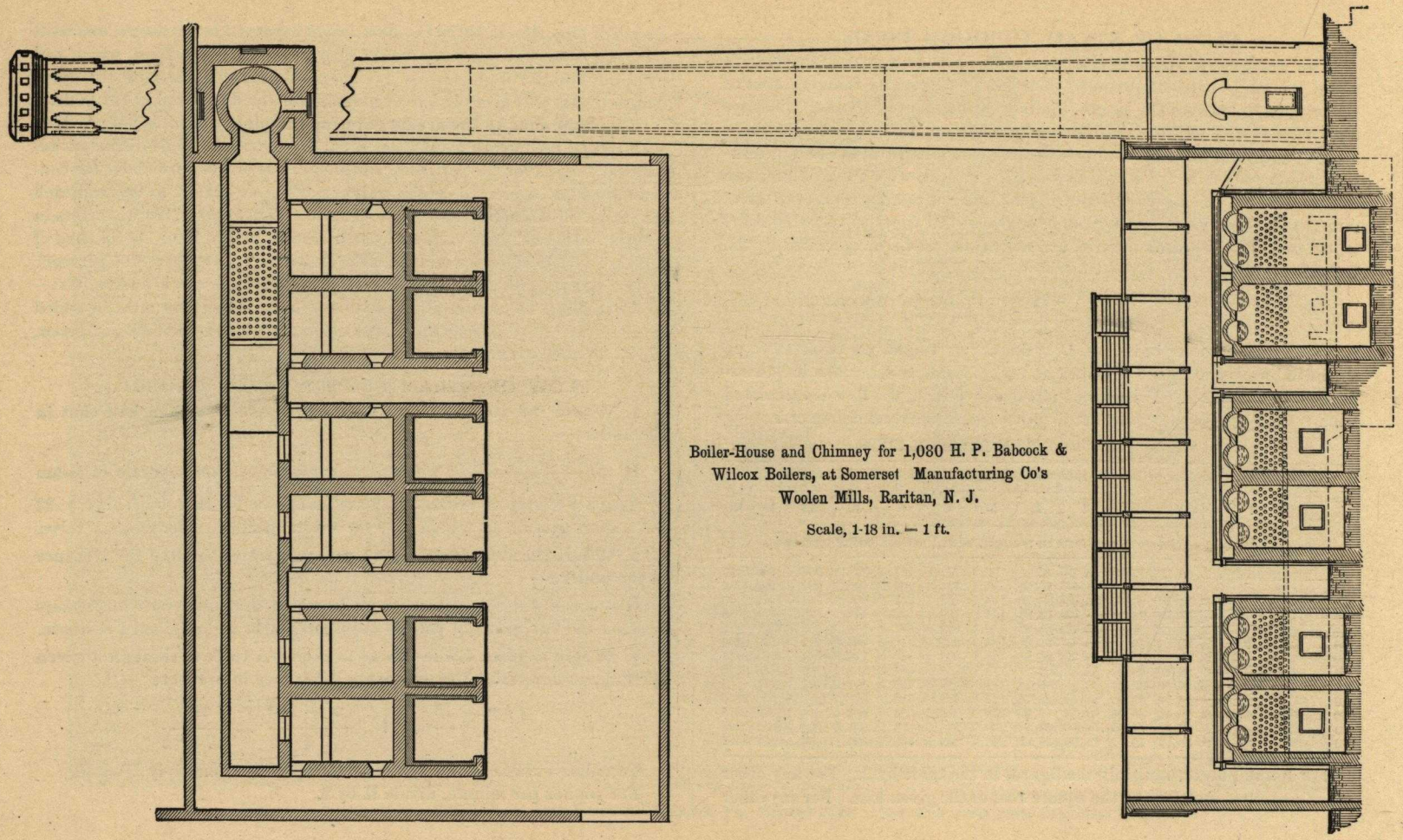
2. Where the steam flows into a pressure more than half the pressure in the boiler:—

$H = 3.8\ a\ k \sqrt{(p + 15 - d)\ d}$; in which d = difference in pressure between the two sides, in pounds per square inch, and a, p and k as above.

3. Where a given horse-power is required to flow through a given opening, to determine the necessary difference in pressure:—

$$d = \frac{p + 15}{2} - \sqrt{\frac{(p + 15)^2}{4} - \frac{H^2}{14\ a^2\ k}}$$

To reduce either of the above to pounds per hour, multiply H by 30. For pounds per minute, divide H by 2.



Boiler-House and Chimney for 1,080 H. P. Babcock & Wilcox Boilers, at Somerset Manufacturing Co's Woolen Mills, Raritan, N. J.

Scale, 1-18 in. = 1 ft.

COVERING FOR BOILERS, STEAM PIPES, &c.

The losses by radiation from unclothed pipes and vessels containing steam is considerable, and in the case of pipes leading to steam engines, is magnified by the action of the condensed water in the cylinder. It therefore is important that such pipes should be well protected.

Table of **Loss of Heat from Steam Pipes,** naked and clothed with Wool or Hair Felt, of different thicknesses. Steam pressure, 75lbs. External air, 60°.

Thickness of Covering in inches.	Outside Diameter of Pipe, without Felt.														
	2 in. diameter.			4 in. diameter.			6 in. diameter.			8 in. diameter.			12 in. diameter.		
	Loss in units per foot run per hour.	Ratio of Loss.	Feet in length per H. P. lost.	Loss in units per foot run per hour.	Ratio of Loss.	Feet in length per H. P. lost.	Loss in units per foot run per hour.	Ratio of Loss.	Feet in length per H. P. lost.	Loss in units per foot run per hour.	Ratio of Loss.	Feet in length per H. P. lost.	Loss in units per foot run per hour.	Ratio of Loss.	Feet in length per H. P. lost.
0	219.0	1.00	132	390.8	1.00	75	624.1	1.000	46	729.8	1.000	40	1077.4	1.000	26
¼	100.7	.46	288	180.9	.46	160									
½	65.7	.30	441	117.2	.30	247	187.2	.300	154	219.6	.301	132	301.7	.280	92
1	43.8	.20	662	73.9	.18	392	111.0	.178	261	128.3	.176	225	185.3	.172	157
2	28.4	.13	1020	44.7	.11	648	66.2	.106	438	75.2	.103	385	98.0	.091	294
4	19.8	.09	1464	28.1	.07	1031	41.2	.066	703	46.0	.063	630	60.3	.056	486
6				23.4	.06	1238	33.7	.054	860	34.3	.047	845	45.2	.042	642

There is a wide difference in the value of different substances for protecting from radiation, their value varying nearly in the inverse ratio of their conducting power for heat, up to their ability to transmit as much heat as the surface of the pipe will radiate, after which they become detrimental, rather than useful, as covering. This point is reached nearly at baked clay or brick.

Table of the **conducting power** of various substances, from PÉCLET:

Substance.	Conducting Power.	Substance.	Conducting Power.	Substance.	Conduct'g Power.
Blotting Paper ...	.274	Wood Ashes.....	.531	India Rubber....	1.37
Eiderdown.....	.314	Straw	.563	Wood, with fibre.	1.40
Cotton or Wool, any density ..	.323	Charcoal Powder	.636	Plaster of Paris..	3.86
		Wood, across fibre	.83	Baked Clay.....	4.83
Hemp, Canvas ...	.418	Cork.....	1.15	Glass.....	6.6
Mahogany Dust ..	.523	Coke, pulverized	1.29	Stone.....	13.68

A smooth or polished surface is of itself a good protection—polished tin or Russia iron having a ratio, for radiation, of 53 to 100 for cast iron. Mere color makes but little difference.

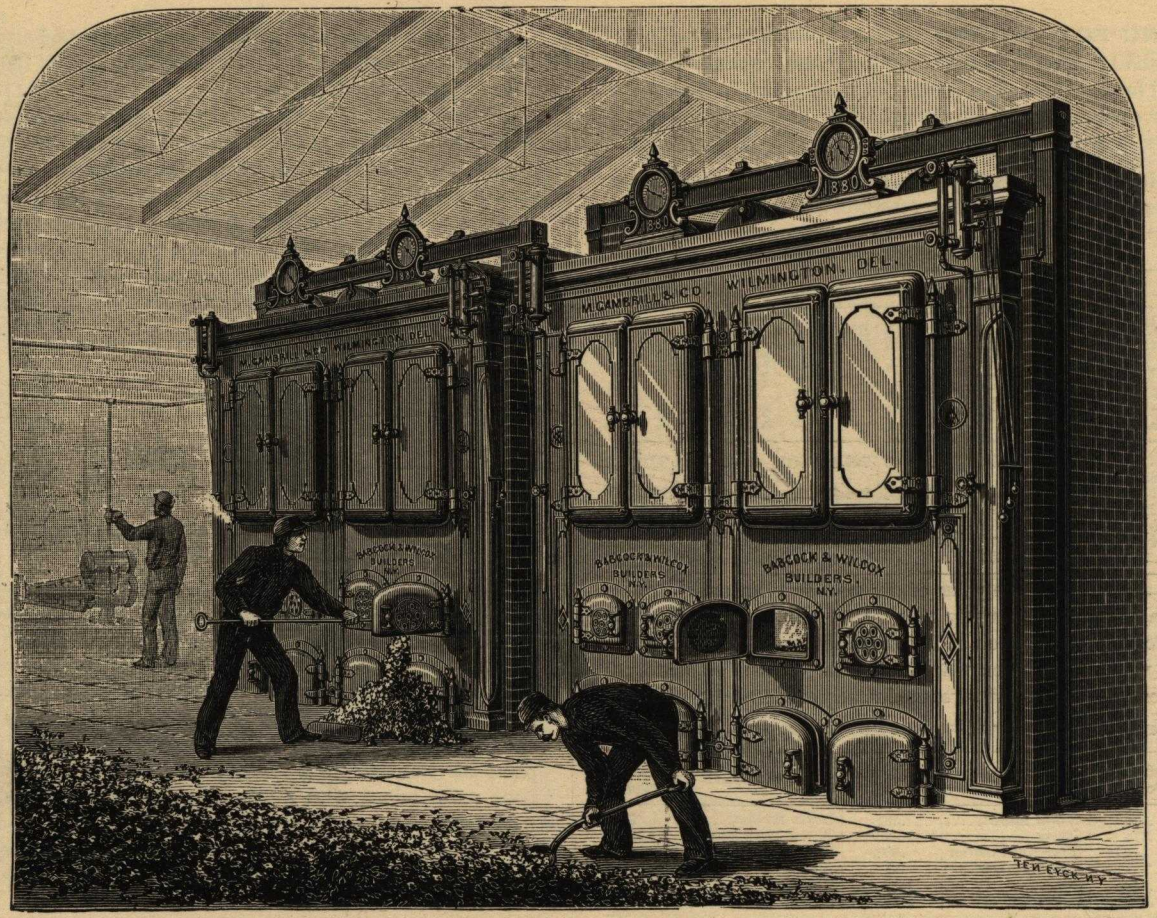
Hair or wool felt has the disadvantage of becoming soon charred from the heat of steam at high pressure, and sometimes of taking fire therefrom. This has led to a variety of **"cements"** for covering pipes—composed generally of clay mixed with different substances, as asbestos, paper fibre, charcoal, etc. A series of careful experiments, made at the Mass. Institute of Technology in 1871, showed the condensation of steam in a pipe covered by one of them, as compared with a naked pipe, and one clothed with hair felt, was 100 for the naked pipe, 67 for the "cement" covering, and 27 for the hair felt.

Table of **Relative Value** of **Non-Conductors,** from experiments by CHAS. E. EMERY, Ph. D.

Non-Conductor.	Value.	Non-Conductor.	Value.	Non-Conductor.	Value.
Wool Felt	1.000	Charcoal	.632	Asbestos	.363
Mineral Wool No. 2..	.832	Pine Wood, across fibre .	.553	Coal Ashes	.345
Do. with tar	.715	Loam, dry and open.....	.550	Coke in lumps ..	.277
Sawdust	.680	Slacked Lime	.480	Air space, undivided	.136
Mineral Wool No. 1..	.676	Gas House Carbon	.470		

"Mineral wool," a fibrous material made from blast furnace slag, is a good protection, and is incombustible.

A cheap jacketing for steam pipes, but a very efficient one, may be applied as follows: First wrap the pipe in asbestos paper—though this may be dispensed with; then lay slips of wood lengthways, from 6 to 12 according to size of pipe—binding them in position with wire or cord; and around the framework thus constructed wrap roofing paper, fastening it by paste or twine. For flanged pipe, space may be left for access to the bolts, which space should be filled with felt. If exposed to weather, use tarred paper—or paint the exterior. A **French plan** is to cover the surface with a rough flour paste mixed with sawdust until it forms a moderately stiff dough. Apply with a trowel in layers of about ¼ inch thick—give 4 or 5 layers in all. If iron surfaces are well cleaned from grease, the adhesion is perfect. For copper, first apply a hot solution of clay in water. A coating of tar will render the composition impervious to the weather.



500 H. P. Babcock & Wilcox Boilers at M. Gambrill & Co's Cotton Mills, Wilmington, Del Erected 1880.

CARE OF BOILERS.

The following rules are compiled from those issued by various Boiler Insurance Companies in this country and Europe, supplemented by our own experience. They are applicable to *all boilers*, except as otherwise noted.

ATTENTION NECESSARY TO SECURE SAFETY.

[Though the Babcock & Wilcox Boilers are not liable to destructive explosion, the same care should be exercised to avoid possible damage to boiler, and expensive delays.]

1. **Safety Valves.**—Great care should be exercised to see that these valves are ample in size and in working order. *Overloading* or *neglect* frequently lead to the most disastrous results. Safety valves should be tried at least once every day to see that they will act freely.

2. **Pressure Gauge.**—The steam gauge should stand at zero when the pressure is off, and it should show same pressure as the safety valve when that is blowing off. If not, then one is wrong, and the gauge should be tested by one known to be correct.

3. **Water Level.**—The first duty of an engineer before starting, or at the beginning of his watch, is to see that the water is at the proper height. Do not rely on glass gauges, floats or water alarms, but try the gauge cocks. If they do not agree with water gauge, learn the cause and correct it. Water level in Babcock & Wilcox boilers should be at centre of drum, which is usually at middle gauge. It should not be carried above.

4. **Gauge Cocks and Water Gauges** must be kept clean. Water gauge should be blown out frequently, and the glasses and passages to gauge kept clean. The Manchester, Eng., Boiler Association attribute more accidents to inattention to water gauges, than to all other causes put together.

5. **Feed Pump or Injector.**—These should be kept in perfect order, and be of ample size. No make of pump can be expected to be continuously reliable without regular and careful attention. It is always safe to have two means of feeding a boiler. Check valves, and self-acting feed valves should be frequently examined and cleaned. Satisfy yourself frequently that the valve is acting when the feed pump is at work.

6. **Low Water.**—In case of low water, immediately cover the fire with ashes (wet if possible) or any earth that may be at hand. If nothing else is handy use fresh coal. Draw fires as soon as it can be done without increasing the heat. Neither turn on the feed, start or stop engine, or lift safety-valve until fires are out, and the boiler cooled down.

7. **Blisters and Cracks.**—These are liable to occur in the best plate iron. When the first indication appears there must be no delay in having it carefully examined and properly cared for.

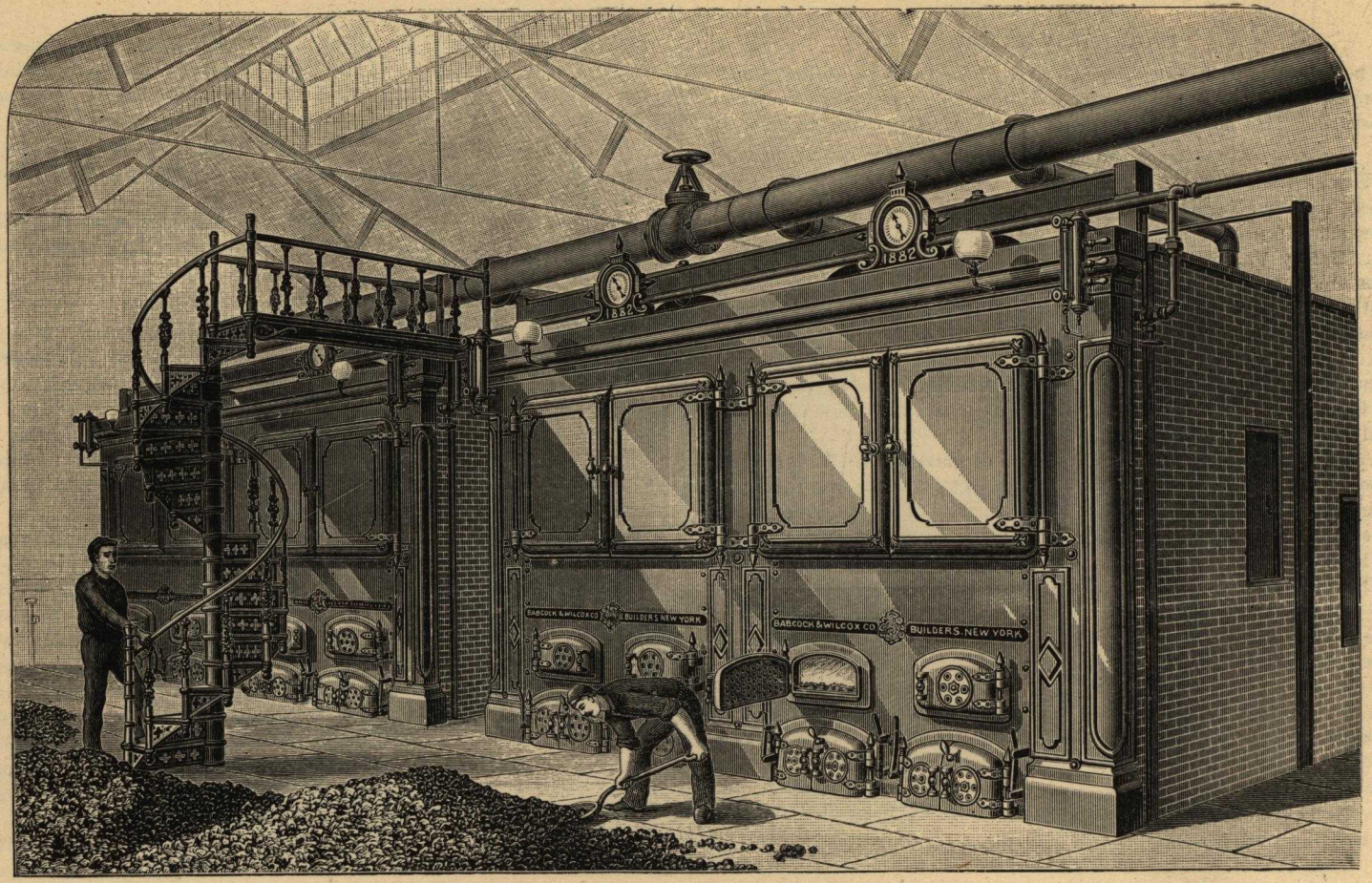
8. **Fusible Plugs,** when used, must be examined when the boiler is cleaned, and carefully scraped clean on both the water and fire sides, or they are liable not to act.

ATTENTION NECESSARY TO SECURE ECONOMY.

9. **Firing.**—Fire evenly and regularly, a little at a time. Moderately thick fires are most economical, but thin firing must be used where the draught is poor. Take care to keep grates evenly covered, and allow no air-holes in the fire. Do not "clean" fires oftener than necessary. With bituminous coal, a "coking fire," *i. e.* firing in front and shoving back when coked, gives best results. In the **Babcock & Wilcox smokeless furnace,** be sure that the coke covers the back grate, and that no fresh coal ever gets back of the hanging bridge.

10. **Cleaning.**—All heating surfaces must be kept clean outside and in, or there will be a serious waste of fuel. The frequency of cleaning will depend on the nature of fuel and water. As a rule, never allow over $\frac{1}{16}$ inch scale or soot to collect on surfaces between cleanings. Hand-holes should be frequently removed and surfaces examined, particularly in case of a new boiler, until proper intervals have been established by experience.

The Babcock & Wilcox boiler is provided with extra facilities for cleaning, and with a little care can be kept up to its maximum efficiency, where tubulars or locomotive boilers would be quickly destroyed. For inspection, remove the hand-holes at both ends of the tubes, and by holding a lamp at one end and looking in at the other, the condition of the surface can be fully seen. Push the scraper through the tube to remove sediment, or if the scale is hard use the chipping scraper made for that purpose. Water through a hose will facilitate the operation. In replacing hand-hole caps,



832 H. P. Babcock & Wilcox Boilers for Bemis & McAvoy Brewing Co., Chicago, Ill.

clean the surfaces without scratching or bruising, smear with oil, and screw up tight. Examine mud-drum and remove the sediment therefrom.

The *exterior* of tubes can be kept clean by the use of blowing pipe and hose through openings provided for that purpose. In using smoky fuel, it is best to occasionally brush the surfaces when steam is off.

11. Hot Feed Water.—Cold water should never be fed into any boiler when it can be avoided, but when necessary it should be caused to mix with the heated water before coming in contact with any portion of the boiler.

12. Foaming.—When foaming occurs in a boiler, checking the outflow of steam will usually stop it. If caused by dirty water, blowing down and pumping up will generally cure it. In cases of violent foaming, check the draft and cover the fires. Babcock & Wilcox boilers never foam with good water, unless the water is carried too high. If found to carry over water, lower the water line. It should not be carried above centre line of drum.

13. Air Leaks.—Be sure that all openings for admission of air to boiler or flues, except through the fire, are carefully stopped. This is frequently an unsuspected cause of serious waste.

14. Blowing Off.—If feed water is muddy or salt, blow off a portion frequently, according to condition of water. Empty the boiler every week or two, and fill up afresh. When surface blow-cocks are used, they should be often opened for a few minutes at a time. Make sure no water is escaping from the blow-off cock when it is supposed to be closed. Blow-off cocks and check-valves should be examined every time the boiler is cleaned.

ATTENTION NECESSARY TO SECURE DURABILITY.

15. Leaks.—When leaks are discovered, they should be repaired as soon as possible.

16. Blowing Off.—Never empty the boiler while the brickwork is hot.

17. Filling Up.—Never pump cold water into a hot boiler. Many times leaks, and in shell boilers, serious weaknesses are caused in this way.

18. Dampness.—Take care that no water comes in contact with the exterior of the boiler from any cause, as it tends to corrode and weaken the boiler. Beware of all dampness in seatings or coverings.

19. Galvanic Action.—Examine frequently parts in contact with copper or brass, where water is present, for signs of corrosion. If water is salt or acid, some metallic zinc placed in the boiler will usually prevent corrosion, but it will need attention and renewal from time to time.

20. Rapid Firing.—In boilers with thick plates or seams exposed to the fire, steam should be raised slowly, and rapid or intense firing avoided. With thin water-tubes, however, and adequate water circulation, no damage can come from that cause.

21. Standing Unused.—If a boiler is not required for some time, empty and dry it thoroughly. If this is impractical, fill it quite full of water, and put in a quantity of common washing soda.

22. General Cleanliness.—All things about the boiler room should be kept clean and in good order. Negligence tends to waste and decay.

BOILER TESTS.

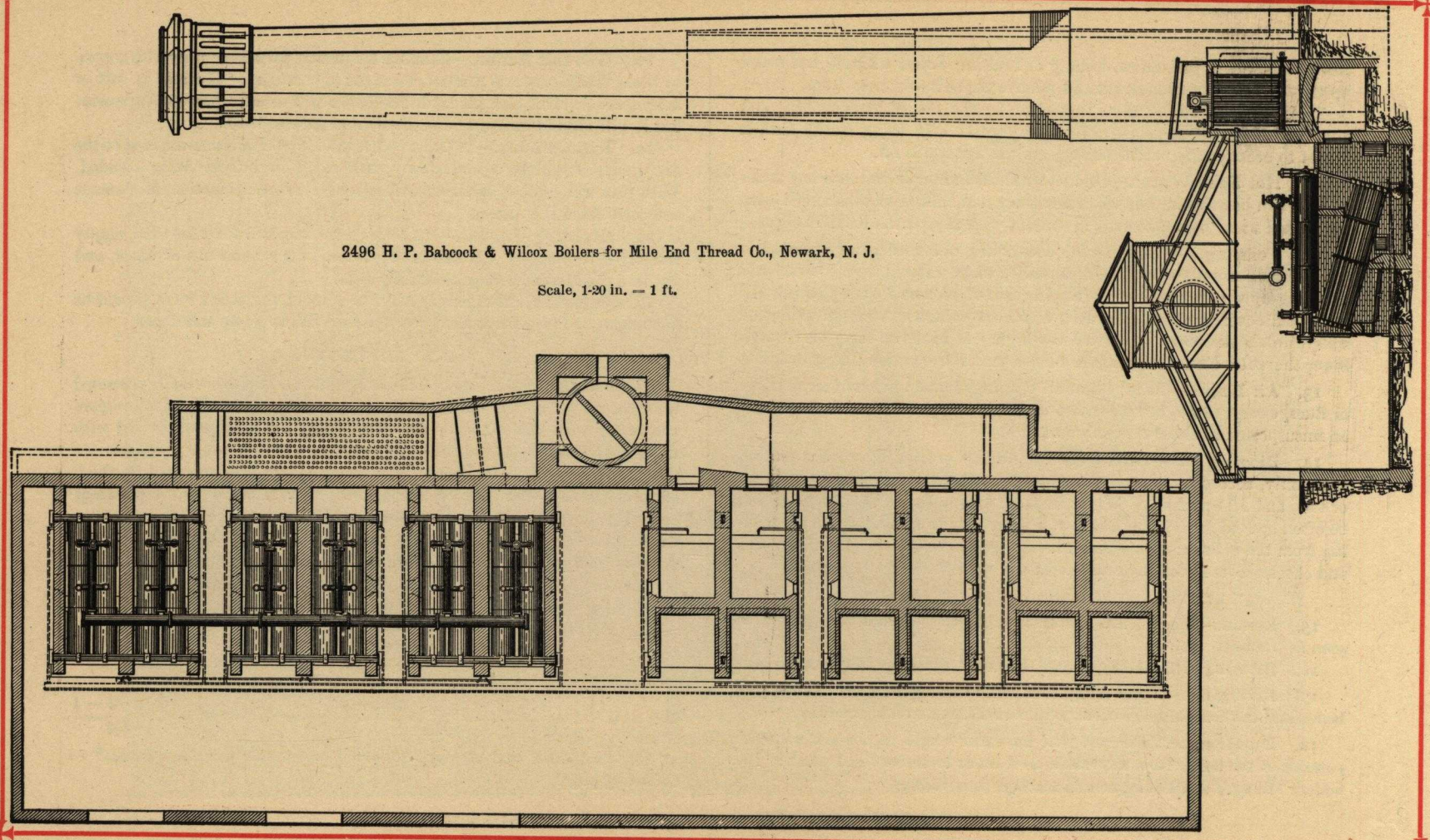
The amount of water evaporated per pound of coal is universally conceded to be the proper measure of the efficiency of a boiler, but in order to compare one boiler with another, they should have equally good coal, be fed with water at the same temperature and furnish steam at the same pressure. As this is impractical in making tests, a standard has been accepted to which all tests should be brought for comparison. This is called the "**equivalent evaporation from and at 212°" per pound of combustible**; that is, what the evaporation would have been if the coal had been without ash, the feed water at boiling point and the steam delivered at atmospheric pressure.

This may be determined from any given test, by the following formula:—

Let W = the observed evaporation per pound of combustible.
" t = the observed temperature of feed.
" T = the temperature of steam at the observed pressure.
" H = the total heat of steam at the observed pressure.
" W′ = equivalent evaporation from and at 212°.

$$W' = W\left\{1 + \frac{0.3\,(T - 212) + (212 - t)}{966}\right\} \quad \text{or,} \quad W' = W \times \frac{H + 32 - t}{966}$$

The value of T and H may be found by reference to "steam tables" on following page.



2496 H. P. Babcock & Wilcox Boilers for Mile End Thread Co., Newark, N. J.

Scale, 1-20 in. = 1 ft.

PROPERTIES OF SATURATED STEAM.

Ice is liquified and becomes water at 32° F. Above this point water increases in temperature up to the steaming point, nearly at the rate of 1° for each unit of heat added per pound of water. The steaming point, (212° at atmospheric pressure), rises as the superimposed pressure increases.

For each unit of heat added above the steaming point, a portion of the water is converted into steam, having the same temperature and the same pressure as that at which it is evaporated. The heat so absorbed is called "Latent Heat." The amount of heat rendered latent by each pound of water in becoming steam varies at different pressures, decreasing as the pressure increases. This latent heat added to the sensible heat (or thermometric temperature), constitutes the "Total Heat." The "total heat" being greater as the pressure increases, it will take more heat, and consequently more fuel, to make a pound of steam the higher the pressure.

The following table gives the properties of steam at different pressures—from 1 lb. to 400 lbs. "total pressure," *i. e.*, above vacuum.

The gauge pressure is about 15 pounds less than the total pressure, so that in using this table, 15 must be added to the pressure as given by the steam gauge.

The column of Temperatures, gives the thermometric temperature of steam and boiling point at each pressure.

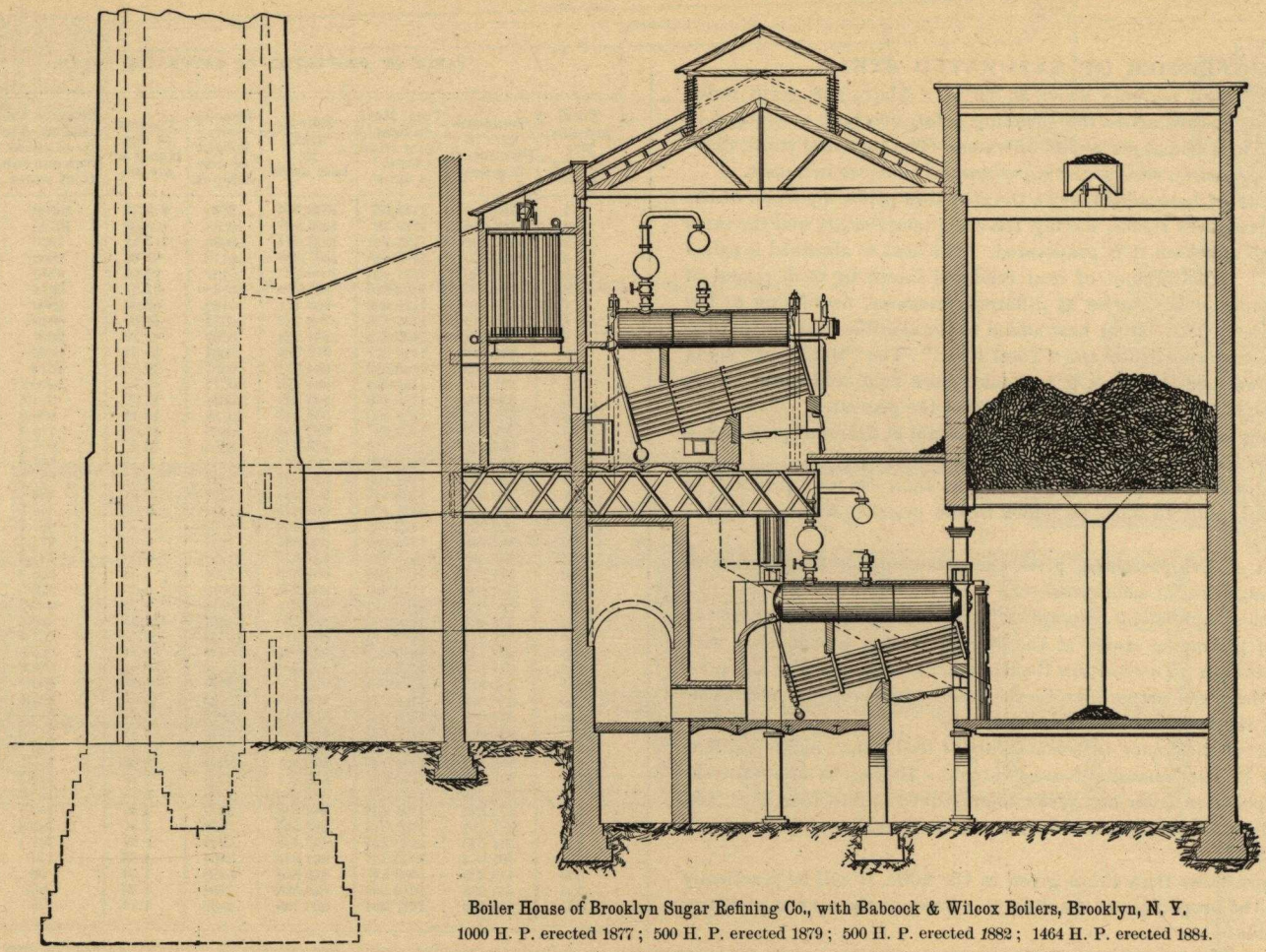
The "Factor of equivalent evaporation" shows the proportionate cost in heat or fuel, of producing steam at the given pressure, as compared with atmospheric pressure. To ascertain the equivalent evaporation at any pressure, multiply the given evaporation by the factor of its pressure, and divide the quotient by the factor of the desired pressure.

Each degree of difference in temperature of feed water, makes a difference of .00104 in the amount of evaporation. Hence, to ascertain the equivalent evaporation from any other temperature of feed than 212°, add to the factor given as many times .00104 as the temperature of feed water is degrees below 212°.

For other pressures than those given in the table, it will be practically correct to take the proportion of the difference between the nearest pressures given in the table.

TABLE OF PROPERTIES OF SATURATED STEAM.

Total pressure per square inch.	Temperature in Fahrenheit degrees.	Total Heat in heat units from water at 32° F.	Latent heat, in heat units.	Density or weight of one cubic ft.	Volume of one pound of steam.	Relative volume, or cub. ft. of steam from one cub. ft. of water.	Factor of equivalent evaporation from water at 212°.
1	102	1113.05	1042.964	.0030	330.36	20620	0.965
2	126.266	1120.45	1026.010	.0058	172.08	10720	0.972
3	141.622	1125.131	1015.254	.0085	117.52	7326	0.977
4	153.070	1128.625	1007.229	.0112	89 62	5600	0.981
5	162.330	1131.449	1000.727	.0137	72.66	4535	0.984
6	170.123	1133.826	995.249	.0163	61.21	3814	0.986
7	176 910	1135.896	990.471	.0189	52.94	3300	0.988
8	182.910	1137.726	986.245	.0214	46.69	2910	0.990
9	188.316	1139.375	982.434	.0239	41.79	2607	0.992
10	193.240	1140.877	978.958	.0264	37.84	2360	0.994
15	213 025	1146.912	964.973	.0387	25.85	1612	1.000
20	227.917	1151.454	954.415	.0511	19.72	1220.3	1.005
25	240.000	1155.139	945 825	.0634	15.99	984.8	1.008
30	250.245	1158.263	938.925	.0755	13.46	826.8	1.012
35	259.176	1160.987	932.152	.0875	11.65	713.4	1.015
40	267.120	1163.410	926.472	.0994	10.27	628.2	1.017
45	274.296	1165.600	921.334	.1111	9.18	561.8	1.017
50	280.854	1167.600	916.631	.1227	8.31	508.5	1.021
55	286.897	1169.442	912.290	.1343	7.61	464.7	1.023
60	292.520	1171.158	908.247	.1457	7.01	428.5	1.025
65	297.777	1172.762	904.462	.1569	6.49	397.7	1.027
70	302.718	1174.269	900.899	.1681	6.07	371.2	1.028
75	307.388	1175.692	897.526	.1792	5.68	348.3	1.030
80	311.812	1177.042	894.330	.1901	5.35	328.3	1.031
85	316.021	1178.326	891.286	.2010	5.05	310.5	1.033
90	320.039	1179.551	888.375	.2118	4.79	294.7	1.034
95	323.884	1180.724	885.588	.2224	4.55	280.6	1.035
100	327.571	1181.849	883 914	.2330	4.33	267.9	1.036
105	331.113	1182.929	880.342	.2434	4.14	265.5	1.037
110	334.523	1183.970	877 865	.2537	3.97	246.0	1.038
115	337.814	1184 974	875.472	.2640	3.80	236.3	1.039
120	340.995	1185.944	873 155	.2742	3.65	227.6	1.040
125	344.074	1186 883	870.911	.2842	3.51	219.7	1.041
130	347.059	1187.794	868.735	.2942	3.38	212.3	1.042
140	352.757	1189.535	864 566	.3138	3.16	199.0	1.044
150	358.161	1191.180	860 621	.3340	2.96	187.5	1.046
160	363.277	1192.741	856.874	.3520	2.79	177.3	1.047
170	368.158	1194.228	853 294	.3709	2.63	168.4	1.049
180	372.822	1195.650	849 869	.3889	2.49	160.4	1.051
190	377.291	1197.013	846.584	.4072	2.37	153.4	1.052
200	381.573	1198.319	843.432	.4249	2.26	147.1	1.053
250	401.072	1203.735	831 222	.5464	1.83	114	1.059
300	418.225	1208 737	819.610	.6486	1.54	96	1.064
350	431.956	1212 580	810.690	.7498	1.33	83	1.068
400	444.919	1217.094	800.198	.8502	1.18	73	1.073



Boiler House of Brooklyn Sugar Refining Co., with Babcock & Wilcox Boilers, Brooklyn, N. Y.
1000 H. P. erected 1877; 500 H. P. erected 1879; 500 H. P. erected 1882; 1464 H. P. erected 1884.

WATER AT DIFFERENT TEMPERATURES.

There are four notable temperatures for pure water, viz :—

1. Freezing point at sea level, 32° F. Weight per cub. ft. 62.418 lbs.; per cub. in. .03612 lbs.
2. Point of maximum density, 39.1° F. " " " " 62.425 " " " " .036125 "
3. British standard for spec. gr. 62° F. " " " " 62.355 " " " " .03608 "
4. Boiling point at sea level, 212° F. " " " " 59.760 " " " " .03458 "

A United States Standard gallon holds 231 cubic inches, and 8⅓ lbs. water at 62° Fah.

A British Imperial gallon holds 277.274 cubic inches and 10 lbs. water at 62° Fah.

Sea water, (average,) has a specific gravity of 1.028, boils at 213.2° F., and weighs 64 lbs. per cubic foot at 62° F.

In **solvent power** water has a greater range than any other liquid. For common salt this is nearly constant at all temperatures while it increases with increase of temperature for others, magnesium and sodium sulphates, for instance. Lime salts are more soluble in cold than in hot water, and most of them are deposited at 320°, or less. When frozen into ice, or evaporated into steam, water parts with nearly all substances held in solution.

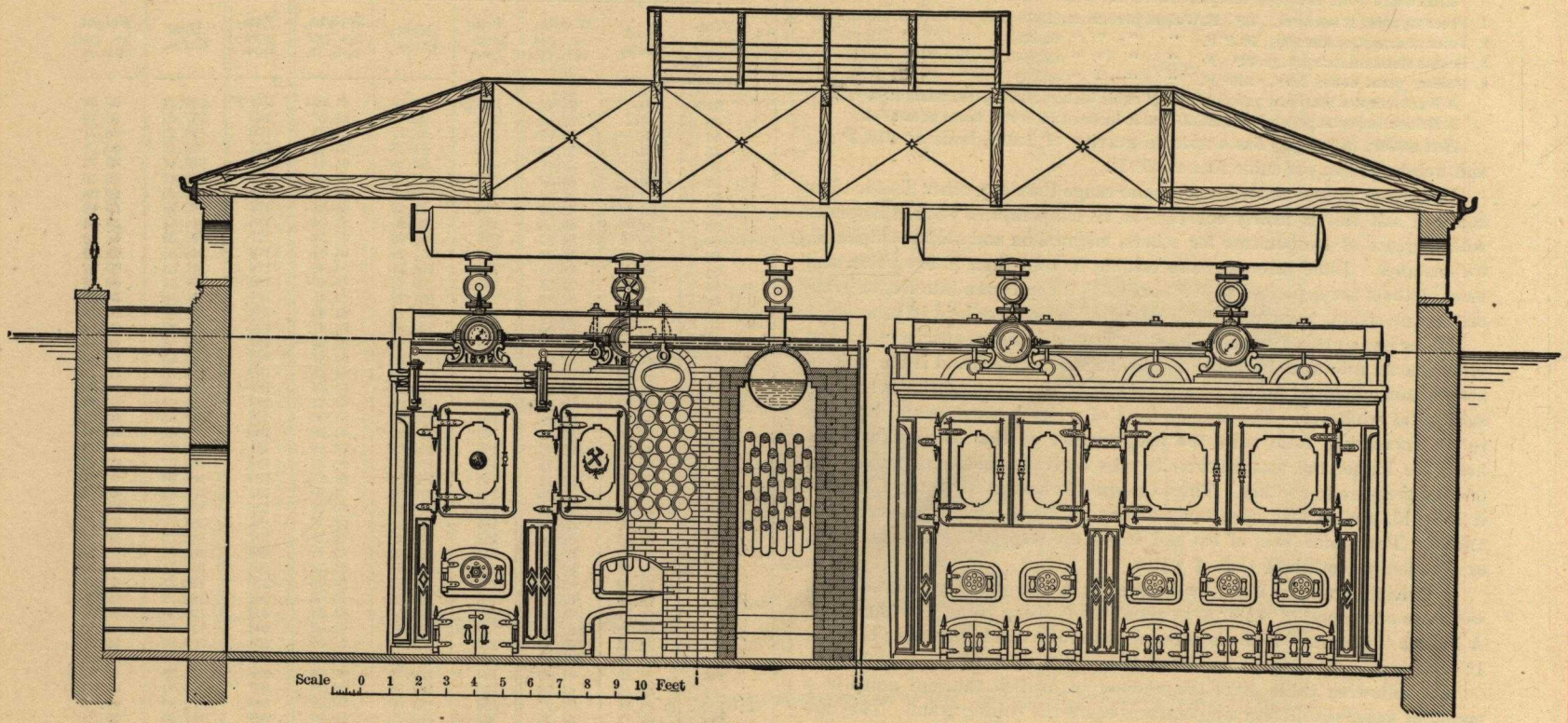
Water has a greater **specific heat,** or heat-absorbing capacity, than any other known substance (bromine and hydrogen excepted) and is the unit of comparison employed for all measurements of the capacities for heat of all substances whatever. The specific heat of water is not constant, but rises in an increasing ratio with the temperature, so that it requires more heat, the higher the temperature, to raise a given quantity of water from one temperature to another. Thus, the specific heat at 32° being 1, at 212° it is 1.013, and at 320° (the temperature of 75 lbs. steam pressure,) it is 1.0294. The specific heat of ice and steam are respectively .504 and .475, or practically about half that of water.

A **British Thermal Unit,** (or **heat unit**) is that quantity of heat which will raise one pound of water at or about the freezing point, 1° Fahrenheit. A French " **Calorie** " is the heat required to raise one kilogramme of water 1° centigrade, and is equal to 3.96832 British thermal units.

The following **table** gives the number of British **thermal units** in a pound of water at different temperatures below the boiling point. They are reckoned above 32° Fah., for, strictly speaking, *water* does not exist below 32° and ice follows another law. The table also gives the **weight per cubic foot,** at each temperature, calculated by Rankine's formula.

HEAT UNITS IN WATER, BETWEEN 32° AND 212° F. AND WEIGHT OF WATER PER CUBIC FOOT.

Temperature.	Heat Units.	Weight, lbs. per cub. ft.	Temperature.	Heat Units.	Weight, lbs. per cub. ft.	Temperature.	Heat Units.	Weight, lbs. per cub. ft.
32°F.	0.	62.42	123°F.	91.16	61.68	168°F.	136.44	60.81
35	3.	62.42	124	92.17	61.67	169	137.45	60.79
40	8.	62.42	125	93.17	61 65	170	138.45	60.77
45	13.	62.42	126	94.17	61.63	171	139.46	60.75
50	18.	62.41	127	95.18	61.61	172	140.47	60.73
52	20.	62.40	128	96.18	61.60	173	141.48	60.70
54	22.01	62.40	129	97.19	61.58	174	142.49	60.68
56	24.01	62.39	130	98.19	61.56	175	143.50	60.66
58	26.01	62.38	131	99.20	61 54	176	144.51	60.64
60	28.01	62.37	132	100.20	61.52	177	145.52	60.62
62	30.01	62.36	133	101.21	61.51	178	146.52	60.59
64	32.01	62.35	134	102.21	61.49	179	147.53	60.57
66	34.02	62.34	135	103.22	61.47	180	148.54	60.55
68	36.02	62.33	136	104.22	61.45	181	149.55	60.53
70	38.02	62.31	137	105.23	61 43	182	150.56	60.50
72	40.02	62.30	138	106.23	61.41	183	151.57	60.48
74	42.03	62.28	139	107.24	61.39	184	152.58	60.46
76	44.03	62.27	140	108.25	61.37	185	153.59	60.44
78	46.03	62.25	141	109.25	61.36	186	154.60	60.41
80	48.04	62.23	142	110.26	61.34	187	155.61	60.39
82	50.04	62.21	143	111.26	61.32	188	156.62	60.37
84	52.04	62.19	144	112.27	61.30	189	157.63	60.34
86	54.05	62.17	145	113.28	61.28	190	158.64	60.32
88	56.05	62.15	146	114.28	61.26	191	159.65	60.29
90	58.06	62.13	147	115.29	61.24	192	160.67	60.27
92	60.06	62.11	148	116.29	61.22	193	161.68	60.25
94	62.06	62.09	149	117.30	61.20	194	162.69	60.22
96	64.07	62.07	150	118.31	61.18	195	163.70	60.20
98	66.07	62.05	151	119.31	61.16	196	164.71	60.17
100	68.08	62.02	152	120.32	61.14	197	165.72	60.15
102	70.09	62.00	153	121.33	61.12	198	166.73	60.12
104	72.09	61.97	154	122.33	61.10	199	167.74	60.10
106	74.10	61.95	155	123.34	61.08	200	168.75	60.07
108	76.10	61.92	156	124.35	61.06	201	169.77	60.05
110	78.11	61.89	157	125.35	61.04	202	170.78	60.02
112	80.12	61.86	158	126.36	61.02	203	171.79	60.00
114	82.13	61.83	159	127.37	61.00	204	172.80	59.97
115	83.13	61.82	160	128.37	60.98	205	173.81	59.95
116	84.13	61.80	161	129.38	60.96	206	174.83	59.92
117	85.14	61.78	162	130.39	60.94	207	175.84	59.89
118	86.14	61.77	163	131.40	60.92	208	176.85	59.87
119	87.15	61.75	164	132.41	60.90	209	177.86	59.84
120	88.15	61.74	165	133.41	60.87	210	178.87	59.82
121	89.15	61.72	166	134.42	60.85	211	179.89	59.79
122	90.16	61.70	167	135.43	60.83	212	180.90	59.76



400 H. P. Babcock & Wilcox Boilers at Columbia College School of Mines. 150 H. P. erected 1879; 250 H. P. erected 1882.

Tests of Babcock & Wilcox Boilers.

Engineering Office of Chas. E. Emery,
No. 7 Warren Street, New York,
Messrs. Babcock & Wilcox, March 21, 1879.

No. 30 Courtlandt Street, New York.

Gentlemen: On the 4th and 5th of February, 1879, I made a trial of the Babcock and Wilcox boilers and Corliss engines in the **Raritan Woolen Mills**, Raritan, N. J., the results of which are shown in the following report:

There were two boilers tested of the water-tube type, manufactured by you and known by your name, rated jointly at 360 horse-power, and reported to contain 4,080 square feet of heating surface, and 103 square feet of grate surface. These boilers were erected side by side and connected so that they could be used separately or conjointly in connection with or independent of a number of Lancashire drop-flue boilers, three boilers of the latter kind having been removed to make room for yours. All the boilers were connected to a single chimney through a Green's economizer in the flue. A large portion of the steam generated appeared to be used in the dye house and for heating purposes. A portion of the boilers were employed, however, to supply steam to two pairs of engines, of equal size, operating the mill, one pair being of the Wright patent, put in many years since, and the other of Corliss make, erected within a year. Each steam cylinder was 20 inches in diameter, with 48 inches stroke of piston. The engines are provided with Bulkley condensers. In the ordinary working of the mill your boilers were used to supply steam to both pairs of engines.

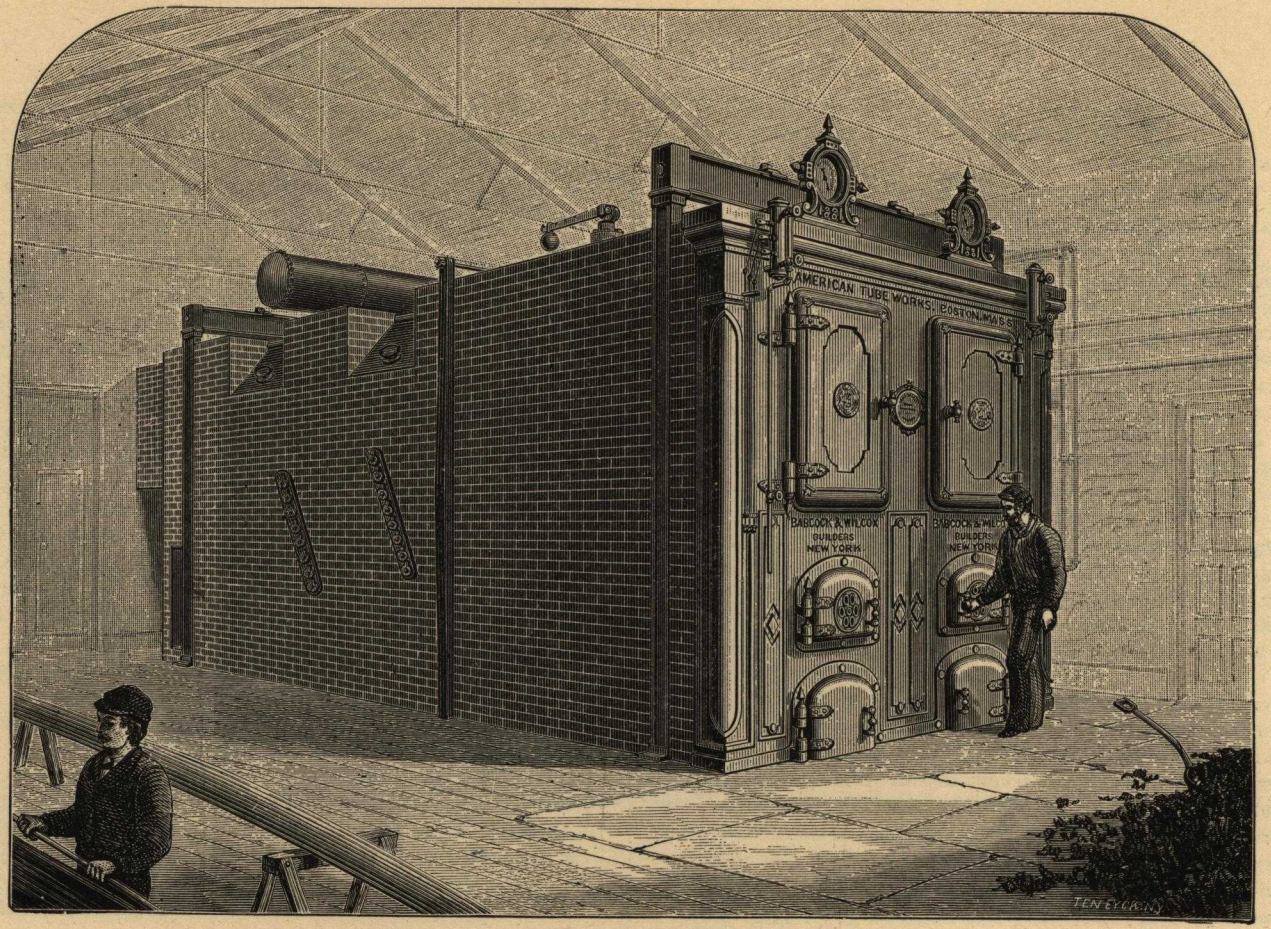
Your contract contained a **guarantee** that the boilers should furnish sufficient steam to develop the rated power (360 H. P.) in a Corliss engine, and that the evaporation should equal at least 9 pounds of water from a temperature of 180° per pound of coal containing not more than 12 per cent. of refuse. In a preliminary trial, part of the load on the Wright engines was transferred to the Corliss engines; but it was soon found that the latter did not require all the steam your boilers would generate economically; so two trials were made, one of 4⅛ hours' duration, using your boilers with reduced draft to supply steam to the Corliss engines only, and taking data to ascertain the economy of the engines; the other of fully 12 hours' duration, using the boiler at *maximum power* on a dull day without forcing the fires, part of the steam being used to operate the Corliss engines, the remainder blown into the pipe system of the other boilers, which were working at a much less pressure.

Trial of the Boilers.

The experiment commenced at 6.01 A. M., and closed at 6.38 P. M. In starting, steam was raised by spreading the banked fires left from the previous day. When the pressure reached 80 pounds the fires were hauled, all refuse removed, and fires started anew with wood, which in calculation has been considered equal in calorific value to $\frac{4}{10}$ its weight of coal. The fires were maintained with coal during the day, finally hauled, allowed to cool, the combustible portion deducted from the coal charged, and the refuse weighed separately. The experiment was closed when the boilers stopped making steam at 80 lbs. pressure, with water in the glass gauges at same height as at starting.

During the trial, all the coal consumed was weighed in an iron wheelbarrow, balanced when empty by a fixed weight, and each barrow load was adjusted at the scale to weigh 200 pounds net. All the water evaporated was measured in a tank provided with a heavy float connected through a fine chain to an index showing a water level on an exterior scale, divided decimally. By weighing water out of the tank, its capacity was found to be 5,172 pounds of water between the limits employed.

A complete record was kept of the coal, water, steam pressure and various temperatures, and the quality of the steam was tested with a calorimeter at frequent intervals. The proprietors of the mill took the proper business precaution of stationing observers at each point, who kept entirely independent records, agreeing with those taken by my assistants. The **coal used** was clean nut coal from the Lackawanna region. It had been exposed to the weather during the winter, and when first taken from the pile was wet, but a sufficient quantity for the trial was brought under shelter a few days



100 H. P. Babcock & Wilcox Boilers, at American Tube Works, Boston, Mass. Erected 1880.

in advance, so that the coal actually used was bright and appeared dry. The results of the trial are as follows:—

Average steam pressure,		71.63
Average temperature of fire room,		44.00
" of water in feed tank,		90.47
" " of water entering boiler after passing through a heater in flue,		110.59
" " of up-take boiler No. 1 by pyrometer, (evidently wrong)		381.87
" " of flue beyond feed water heater,		453.23
Wood used in starting fires, 730 lbs., equivalent of coal (730 × .4)		292 lbs.
Coal put in furnaces during experiment,		19,827 "
Total of above,		20,119 "
Combustible in refuse at close of experiment,		820 "
Total coal consumed, including equivalent of wood,		19,299 "
Refuse from coal removed during experiment,		749 "
Refuse from coal at close of experiment,		2,134 "
Total,		2,883 "
Actual percentage of refuse, (2,883 ÷ 19,299 × 100 =)		14.94 per ct.
Combustible consumed, (19,299—2,883 =)		16.416 lbs.
Coal with 12 per cent. refuse agreed upon, equivalent to that actually consumed [16,416 ÷ (100—12) =]		18,654.5 "
Total weight of water actually evaporated at pressure of 71.63 lbs. from temperature 110.59°,		161,573.28 "
Equivalent evaporation at pressure of 70 lbs. from temperature of 180°, as agreed upon,		172,592.58 "
Evaporation per lb. of coal, with 12 per cent. of refuse, at pressure of 70 lbs. from temperature of 180°		**9.252** "
Evaporation per lb. of combustible, atmos. press. from temp. of 212°,		**11.221** "

CALORIMETER TRIALS.

The calorimeter consisted of a simple barrel set on a platform scale. The scale beam was graduated for half-pounds only; but by applying thereto an extra movable weight, one-tenth that of the other, carefully leveling the platform, and in weighing bringing the end of the beam just clear of the guard, it was possible to read to one-tenth, or even .05 of a pound. In an inclined position, through the side of the barrel, was fixed a thermometer graduated to $\frac{1}{4}$ degrees, and readily read to $\frac{1}{8}$ degrees. A small iron propeller on a vertical shaft was arranged in the barrel. In operations, the barrel was nearly filled with cold water, which was heated with steam, when the increase in weight showed the weight of steam taken from the boiler, and the increase in temperature measured the quantity of heat in the steam. The steam was taken from the boiler near the issuing current, through a 2-inch pipe reduced outside of the boiler to $\frac{3}{4}$ of an inch, and again near the outer end by an inserted nipple to $\frac{5}{16}$ of an inch, substantially on the plan recommended in a previous article on the subject.* To the end of the steam-pipe a short piece of hose was connected through a valve; the pipe was carefully felted, and was heated previous to each experiment by wasting steam through it before putting the hose into the calorimeter. The end of the hose was perforated in several directions, to avoid the jar due to condensation.

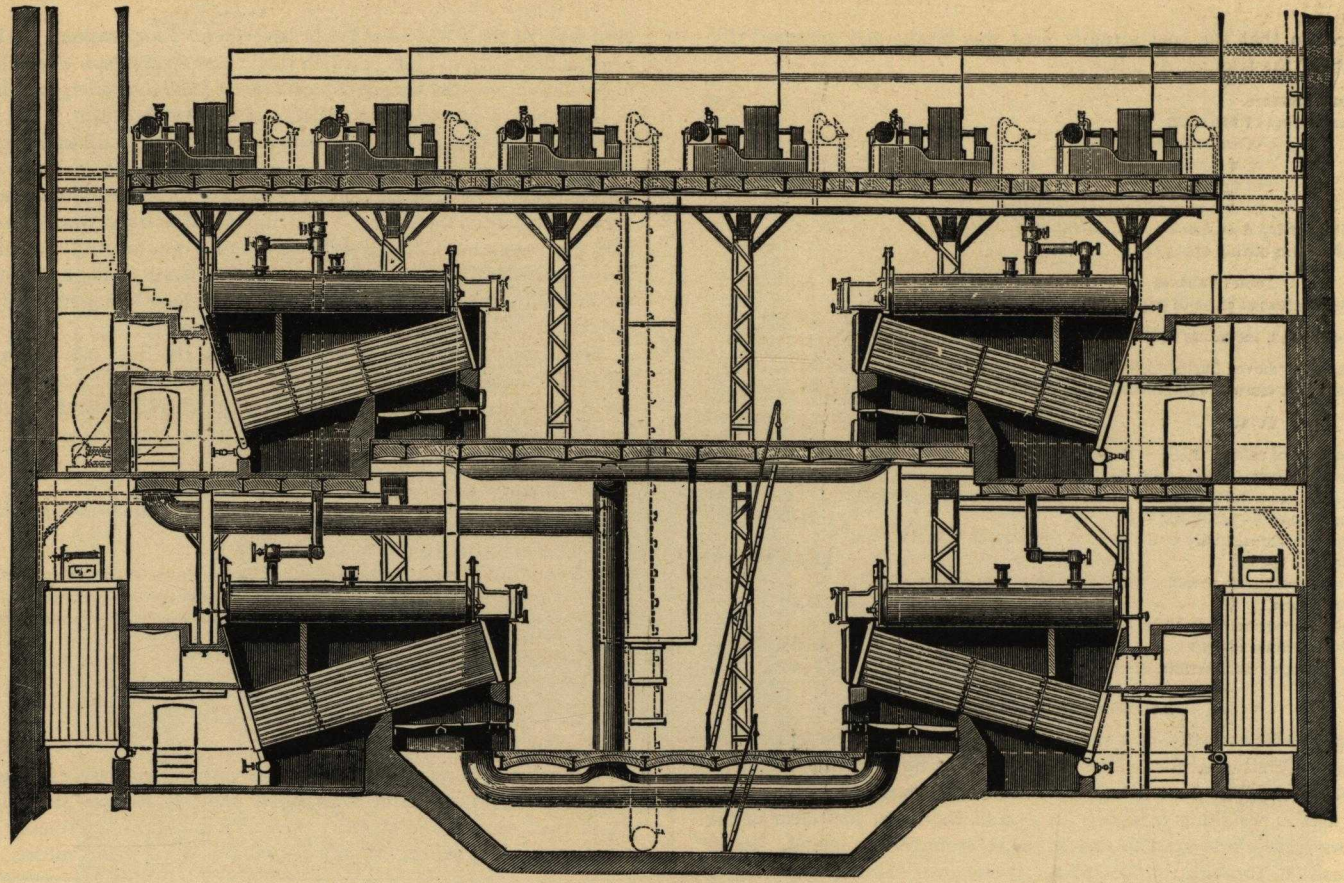
Seventeen experiments were made during the day; one was rejected, in which the thermometer scale was seen to move by bringing the hose too near the instrument. The results were calculated from the records of the remaining sixteen experiments, on the following basis:

Let W = original weight of water in calorimeter.
Let w = weight of water added by heating with steam.
Let T = total heat in water due to the temperature of steam at observed pressure.
Let H = total heat of steam at observed pressure.
Let l = latent heat of steam at observed pressure.
Let t = total heat of water corresponding to temperature of water in calorimeter.
Let t' = total heat in water corresponding to final temperature of water in calorimeter.
Let E = heating efficiency of the steam furnished, compared with saturated steam between the same limits of temperature.
Let Q = quality of steam explained hereafter.

$$\text{Then } E = \frac{W\,(t'-t)}{w\,(H-t')} \quad \ldots\ldots\ldots (1)$$

The value of E was ascertained by the formula separately for each experiment. The **average value was .9916,** showing that the steam lacked but $\frac{84}{100}$ **of 1** per cent. of the quantity of heat required for producing **perfectly dry or saturated steam** between the same limits of temperature.

* Report of Judges, Group XX., Centennial Exhibition, p. 82.



Babcock & Wilcox Boilers in Station 1, Edison Electric Illuminating Co., New York. 900 H. P.

The value of Q may be found directly from the following equation:

$$Q = \frac{1}{l}\left\{\frac{W}{w} - (t' - t) - (T - t')\right\} \ldots\ldots\ldots (2)$$

or, from the average of the heating efficiencies, by the following:

$$Q = 1 - \frac{(H - t')\,(1 - E)}{l} \ldots\ldots\ldots (3)$$

Then when $Q < 1$ percentage of moisture in steam $= 100\,(1 - Q)$.

When $Q > 1$ number of degrees steam is superheated $= 2.0833\,l\,(Q - 1)$.

In the present case $Q = .98955$. Percentage of moisture in steam $= 1.045$.

This is **practically dry steam**, and equal in quality to that furnished by boilers of any type not provided with superheating surface. The experiments show in a gratifying manner that you have succeeded in overcoming a great difficulty often experienced with boilers constructed of a combination of small chambers to reduce the danger of explosion. The deficiency of ordinary boilers in furnishing dry steam is little known, though the economy is materially effected.

ENGINE TRIALS.

The preliminary trial of engines gave the following results:

Duration of experiment,	4.1	hours.
Average steam pressure in boilers,	93.94	pounds.
Average vacuum in condenser,	21.5	inches.
Average revolution of engine per minute,	64.492	
Water evaporated per hour,	8830.244	pounds.
Average initial pressure in steam cylinders,	84.425	"
Mean effective pressure in cylinders,	30.1275	"
Average point of cut off,	.129	stroke.
Average indicated horse-power (both engines),	292.613	
Maximum horse-power shown by a complete set of diagrams,	315.580	
Water per indicated horse-power per hour,	30.177	pounds.

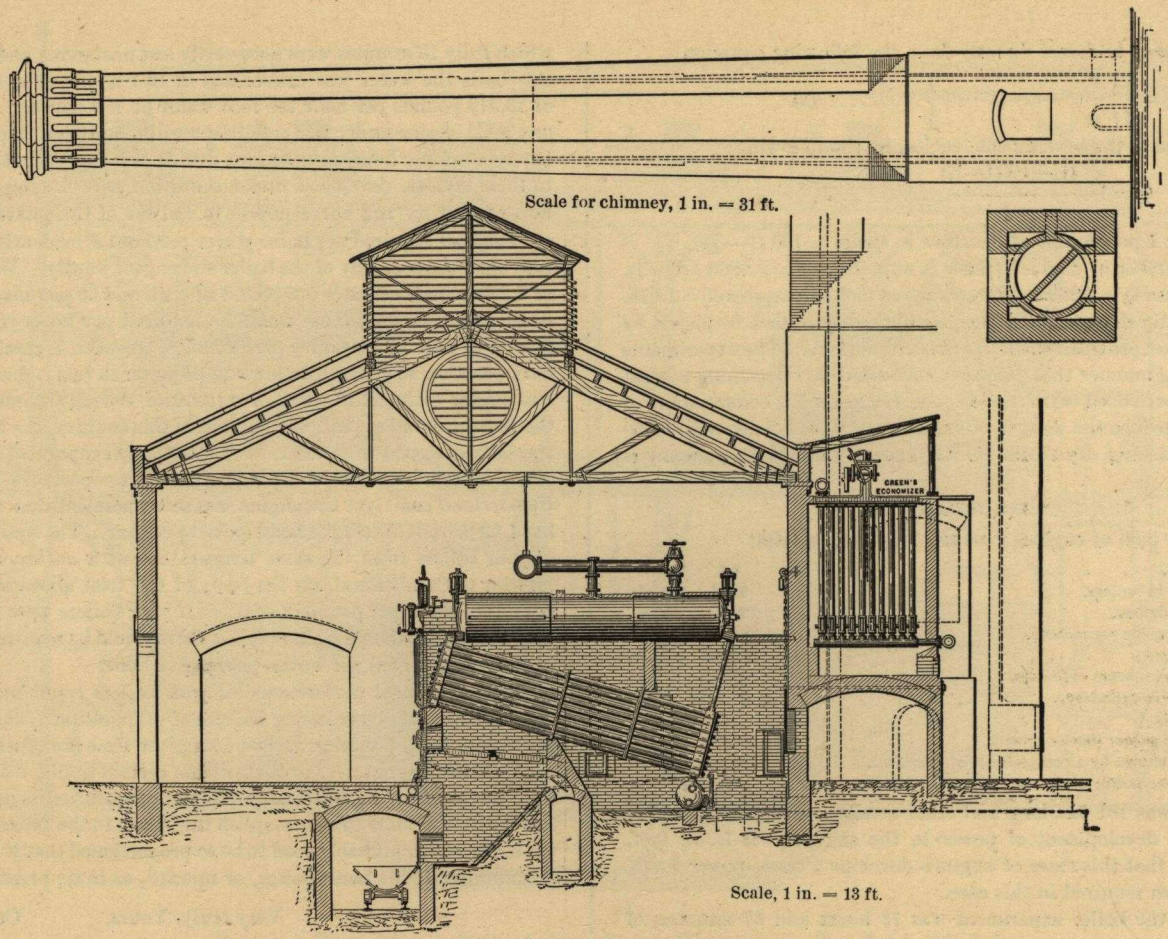
The steam pipe was 131 feet long and other conditions were unfavorable for the economical development of power in the engines. It is, in fact, popularly supposed that this class of engines develops a horse-power for ⅔ the quantity of steam required in this case.

The duration of the boiler experiment was 12 hours and 37 minutes, of which fully 13 minutes were necessarily lost in starting and hauling fires. On this basis the water was evaporated in 12.4 hours, or at the equivalent rate of 13,919 pounds per hour for feed water at 180 degrees. On the basis that any good engine under fair conditions will require but 30 pounds of water per horse-power per hour, your boilers, during this experiment, though not forced to their utmost, developed under condition agreed upon, $13919 \div 30 = 464$ horse-power, or **104 horse-power in excess of the guaranteed power.**

The coal required per horse-power per hour is evidently dependent in any case upon the economy of the boiler and engine jointly. With an evaporation of 9.252 pounds of water per pound of coal, and 30 pounds of water per horse-power in the engine, there would be required per horse-power per hour 3.24 pounds of coal. This boiler performance, however, is rarely obtained in ordinary practice, so generally a low cost of power in fuel is due to using an excellent engine with a fair boiler. For instance, during the official trial of one of the most prominent pumping engines in this country, the boilers, which were specially designed to secure economy, actually evaporated but 8.31 pounds of water at a pressure of 89.4 pounds from a temperature 100° per pound of *Cumberland* coal; yet the engine was so economical that there was required but 1.69 pounds of coal per horse-power per hour. The equivalent evaporation of your boilers from the same temperature with *anthracite nut* coal, much inferior to Cumberland, on the basis of the trial above mentioned, is 8.547 pounds of water per pound of coal; so if your boilers were used in connection with that particular pumping engine, there would be required but **1.64 pounds of the inferior coal per horse-power per hour.**

The economical performance of your boilers could undoubtedly be rendered still greater by reducing the rate of evaporation. The more fuel burned per square foot of heating surface in a given time the greater the quantity of heat lost in the chimney, so that, within certain limits, using proper proportion, the economy increases as the rate of evaporation is diminished, though in a much less ratio. To accomplish this result to the fullest extent, however, the boiler would probably need to be so proportioned that it would not develop a maximum of 464 horse-power, or upward, as in its present form.

Very truly, Yours, CHAS. E. EMERY.



Boiler House and Chimney of Lombard, Ayres & Co., Oil Refinery, Bayonne, N. Y., containing 1830 H. P. Babcock & Wilcox Boilers

TESTS.

The following tests, showing the evaporative efficiency of the Babcock & Wilcox boilers, actual and comparative, with different kinds of fuel, have been made at various times, by different engineers, but all under the same general conditions as the test at the Raritan Woolen Mills, described on page 43, and have been condensed for the purpose of a more ready comparison.

COMPARATIVE TEST,

made at the Oliver Wire Works, Pittsburgh, Pa., March, 1883, by Wm. Kent, M. E., between 416 H. P. Babcock & Wilcox boilers, and eight "two flue" boilers—6 of them being 28 ft. long, 42 inches diameter, 14-inch flues, and 2 of them 26½ ft. long, 40 inches diameter, 14-inch flues. Total grate-surface, 165 ft.

		Babcock & Wilcox.	*Ret. Flue.*
	Date of test,	March 12 to 17.	March 19 to 21.
1.	Coal, bituminous, lump and nut.		
2.	Duration of test, hours	114	40.75
3.	Average steam pressure,	95	95
4.	Average temperature of feed, degrees Fahrenheit	37	180
5.	Water evaporated,	1,512,763.2	880,776
6.	Coal fired,	190,228	147,668
7.	Per cent. of ash,	11	11
8.	Combustible,	169,303	131,425
9.	Grate-surface, square feet,	69.12	165
10.	Coal consumed per square foot of grate per hour,	24.14	21.9
11.	Water evap. per lb. coal under actual conditions,	7.952	5.964
12.	" " " combustible " "	8.826	6.70
13.	" " " coal from and at 212°,	9.709	6.334
14.	" " " combustible " "	**10.909**	**7.115**
15.	Rated horse-power,	416	not given.
16.	Horse-power developed from 212° feed and 70 lbs. steam,	522.84	741.36
17.	Per cent. above rated capacity,	25.68	

Saving in fuel in favor of Babcock & Wilcox:

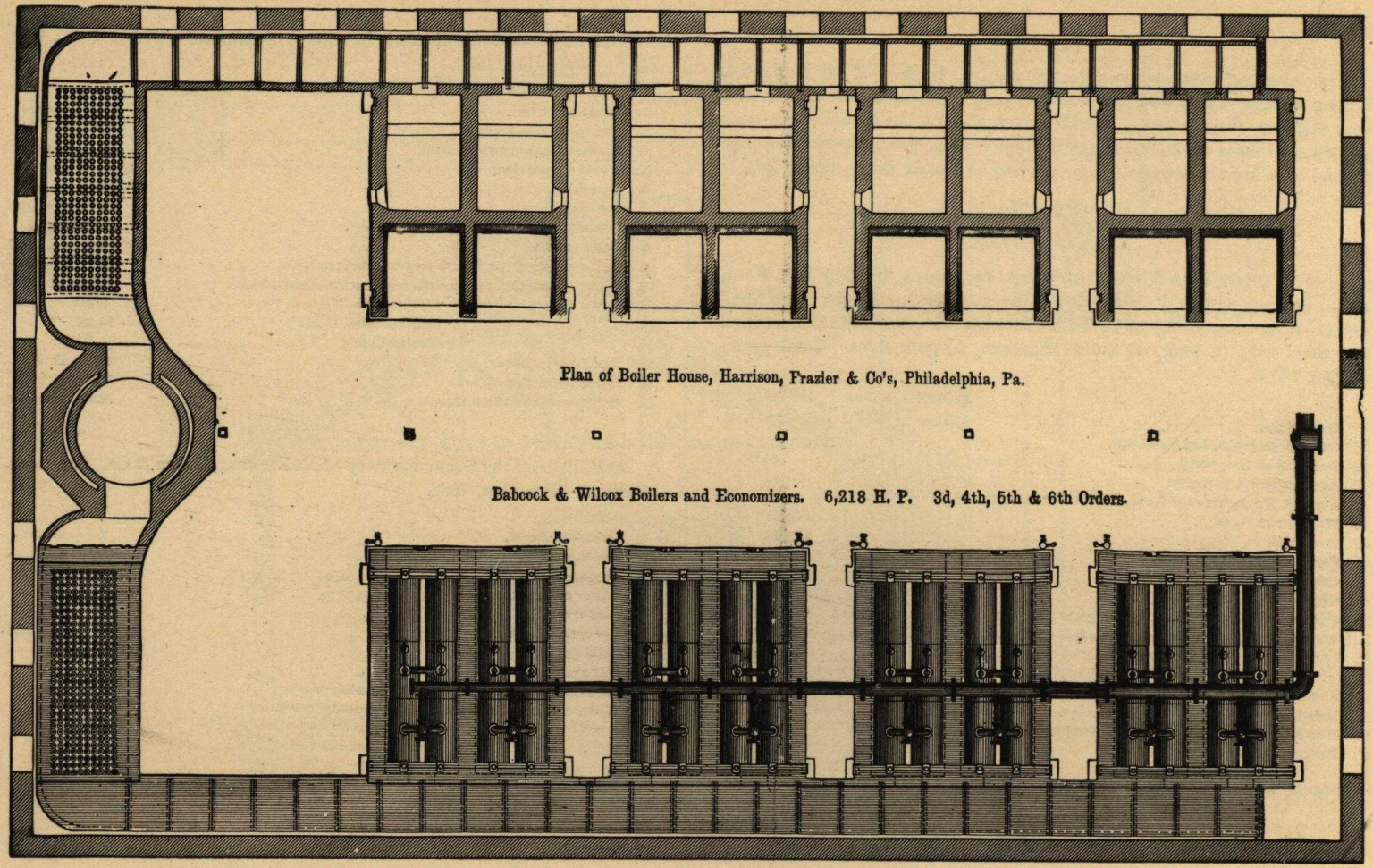
$$9.709 - 6.334 = 3.375; \text{ and } \frac{3.375}{9.709} = 34.76 \text{ per cent.}$$

Test made at the Mill Creek Distillery, Cincinnati, Ohio, by J. W. Hill, M. E., September, 1882.

1.	Coal, Pittsburgh lump, 3d pool.		
2.	Duration of test,	10	hours.
3.	Average steam pressure,	63.975	lbs.
4.	Average temperature of feed,	132	degrees.
5.	Water evaporated,	112,663.455	lbs.
6.	Coal fired,	12,000	"
7.	Per cent. of ash,	4.81	per cent
8.	Combustible,	11,421.75	lbs.
9.	Grate-surface,	43.5	sq. ft.
10.	Coal consumed per square foot of grate per hour,	27.5	lbs.
11.	Water evaporated per lb. coal under actual conditions,	9.388	"
12.	" " " combustible " "	9.863	"
13.	" " " coal from and at 212°,	10.467	"
14.	" " " combustible " "	**10.997**	"
15.	Rated horse-power,	240	H. P.
16.	Horse-power developed,	418.7	"
17.	Per cent. above rated capacity,	74.4	per cent.

Test made at the Sugar Refinery of McEachran, Adam & Co., Greenock, Scotland, November, 1882.

1.	Scotch coal.		
2.	Duration of test,	4	hours.
3.	Average steam pressure,	36	lbs.
4.	Average temperature of feed,	156	degrees.
5.	Water evaporated,	10,426	lbs.
6.	Coal fired,	1,344	"
7.	Per cent. of ash,	7	per cent.
8.	Combustible,	1,2 0	lbs.
9.	Grate-surface,	25	sq. ft.
10.	Coal consumed per square foot of grate per hour,	13.44	lbs.
11.	Water evaporated per lb. coal under actual conditions,	10.73	"
12.	" " " combustible " "	11.53	"
13.	" " " coal from and at 212°,	11.52	"
14.	" " " combustible " "	**12.38**	"
15.	Rated horse-power,	122	H. P.
16.	Horse-power developed,	129	"
17.	Per cent. above rated capacity,	5.7	per cent.



Plan of Boiler House, Harrison, Frazier & Co's, Philadelphia, Pa.

Babcock & Wilcox Boilers and Economizers. 6,218 H. P. 3d, 4th, 5th & 6th Orders.

Test made at the Electric Lighting Station of the Edison Co., 57 Holborn Viaduct, London, October, 1882, by T. A. Fleming, R. S. E., actual working conditions.

1.	Welsh coal.		
2.	Duration of test,	13.5	hours.
3.	Average steam pressure,	66.66	lbs.
4.	Average temperature of feed,	130	degrees.
5.	Water evaporated,	34,800	lbs.
6.	Coal fired,	3,360	"
7.	Per cent. of ash,	7.5	per cent.
8.	Combustible,	3,108	lbs.
9.	Grate-surface,	39 75	sq. ft.
10.	Coal consumed per square foot of grate per hour,	6.261	lbs.
11.	Water evaporated per lb. coal under actual conditions,	10.357	"
12.	" " " combustible " "	11.196	"
13.	" " " coal from and at 212°,	11.527	"
14.	" " " combustible "	**12.46**	"
15.	Rated horse-power,	146	H. P.
16.	Horse-power developed,	119.9	"
17.	Per cent. *below* rated capacity,	23.3	per cent.

Test made at Miami Soap and Oil Works, Cincinnati, Ohio, August, 1882, by J. W. Hill, M. E.

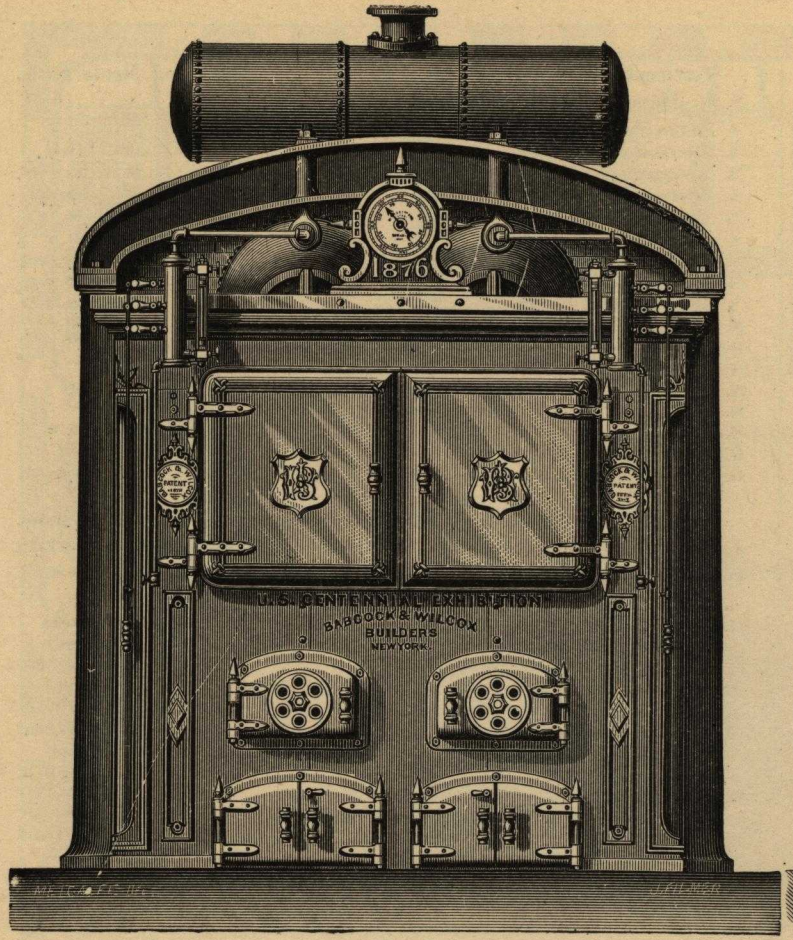
1.	Coal, Pittsburgh *slack*, burned with forced blast.		
2.	Duration of test,	8	hours.
3.	Average steam pressure,	51.73	lbs.
4.	Average temperature of feed,	74.016	degrees.
5.	Water evaporated,	51,220.79	lbs.
6.	Coal fired,	7,365	"
7.	Per cent. of ash,	12.31	per cent.
8.	Combustible,	6,460	lbs.
9.	Grate-surface,	49.833	sq. ft.
10.	Coal consumed per square foot of grate per hour,	14.77	lbs.
11.	Water evaporated per lb. coal under actual conditions,	6.954	"
12.	" " " combustible " "	7.928	"
13.	" " " coal from and at 212°,	8.136	"
14.	" " " combustible "	**9.236**	"
15.	Rated horse-power,	146	H. P.
16.	Horse-power developed,	249.69	"
17.	Per cent. above rated capacity,	71	per cent.

Test made at the works of the Edison Electric Light Co., Menlo Park, N. J., January, 1881, by Charles L. Clarke, M. E.

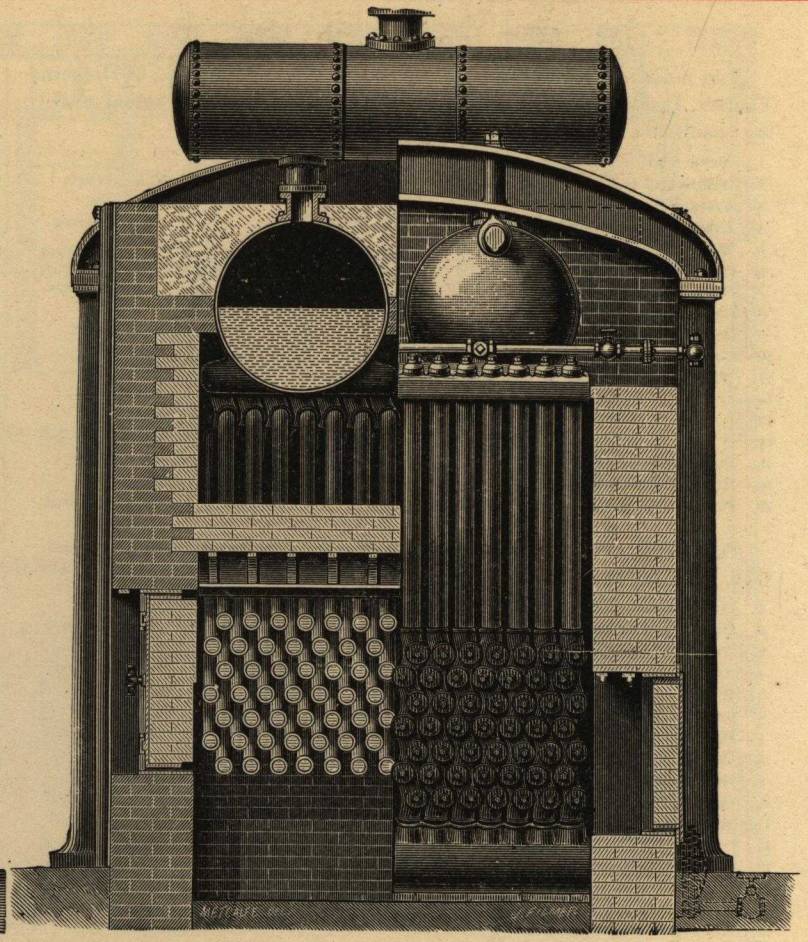
1.	Anthracite coal, egg size.		
2.	Duration of test,	12	hours.
3.	Average steam pressure,	85	lbs.
4.	Average temperature of feed,	195	degrees.
5.	Water evaporated,	28,181	lbs.
6.	Coal fired,	2,998	"
7.	Per cent. of ash,	12.8	per cent.
8.	Combustible,	2,614	lbs.
9.	Grate-surface,	26.83	sq. ft.
10.	Coal consumed per square foot of grate per hour,	9.3	lbs.
11.	Water evaporated per lb. coal under actual conditions,	9.4	"
12.	" " " combustible " "	10.78	"
13.	" " " coal from and at 212°,	9.9	"
14.	" " " combustible "	**11.36**	"
15.	Rated horse-power,	75	H. P.
16.	Horse-power developed,	83	"
17.	Per cent. above rated capacity,	10.6	per cent.

Test made at Harrison & Havemeyer's Sugar Refinery, Philadelphia, January, 1879, by their engineer and usual fireman, under general working conditions. The following gives the average for five days of 24 hours each.

1.	Coal, anthracite, egg size, not screened.		
2.	Duration of test,	120	hours.
3.	Average steam pressure,	62.50	lbs.
4.	Average temperature of feed,	165.8	degrees.
5.	Water evaporated,	733,660	lbs.
6.	Coal fired,	79,147	"
7.	Per cent. of ash,	13.7	per cent.
8.	Combustible,	68,297.5	lbs.
9.	Grate-surface,	50.75	sq. ft
10.	Coal consumed per square foot of grate per hour,	12.99	lbs.
11.	Water evaporated per lb. coal under actual conditions,	9.27	"
12.	" " " combustible " "	10.74	"
13.	" " " coal from and at 212°,	9.71	"
14.	" " " combustible "	**11.6**	"
15.	Rated horse-power,	190	H. P.
16.	Horse-power developed,	220	"
17.	Per cent. above rated capacity,	13.63	per cent.



FRONT VIEW.



VERTICAL SECTION.

Babcock & Wicox Boiler, at U. S. Centennial Exhibition, 1876. 150 H. P.

Test made at the Peacedale Manuf. Co., Peacedale, R. I., December, 1882, by George H. Barrus, M. E.

1.	Coal, ¾ Powelton bituminous, ¼ anthracite screenings.		
2.	Duration of test,	10.25	hours.
3.	Average steam pressure,	77.50	lbs.
4.	Average temperature of feed,	38	degrees.
5.	Water evaporated,	133,096	bs.
6.	Coal fired,	14,287	"
7.	Per cent. of ash	8.8	per cent.
8.	Combustible,	13,025	lbs.
9.	Grate-surface,	70	sq. ft.
10.	Coal consumed per square foot of grate per hour,	20	lbs.
11.	Water evaporated per lb. coal under actual conditions,	9.32	"
12.	" " " combustible " "	10.22	"
13.	" " " coal from and at 212°,	11.32	"
14.	" " " combustible "	**12.42**	"
15.	Rated horse-power,	284	H. P.
16.	Horse-power developed,	447.70	"
17.	Per cent. above rated capacity,	57	per cent.

Tests made at the Genesee Mills, San Francisco, Cal., by A. Worthington, M. E., with coal from British Columbia, Wales, and Washington Territory.

		Feb. 20, 1883.	Feb. 27, 1883.	Feb. 28, 1883.
1.	Coal, bituminous lump,	Wellington, Br. Col.	Cardiff, Wales.	South Prairie, Wash. Ter.
2.	Duration of test,	6 h. 17 m.	7 h. 23 m.	6 h. 35 m.
3.	Average steam pressure, lbs.	119.2	117.68	117.87
4.	Average temperature of feed, degrees Fahr.	59	61 87	61.97
5.	Water evaporated, lbs.	28,329	32,376	30,345
6.	Coal fired, "	3,777	4,032	4,059
7.	Per cent. of ash,	13.78	19 07	13.94
8.	Combustible, lbs.	3,156.5	3,263	3,493
9.	Grate-surface, sq. ft.	21.25	21.25	21.25
10.	Coal consumed per hour per sq. ft. grate, lbs.	28.2	25.6	28.9
11.	Water evaporated per lb. coal, act. con., "	7.5	8.02	7.47
12.	Ditto per lb. combustible, " "	8.97	9.95	8.76
13.	Ditto per lb. coal from and at 212°, "	9.3	9.54	8.88
14.	Ditto per lb. combust. from and at 212°, "	**11.12**	**11.84**	**10.42**
15.	Rated horse-power,	136	136	136
16.	Horse-power developed,	186.1	173.5	182.3
17.	Per cent. above rated capacity,	36.8	27.5	34

COMPARATIVE TEST,

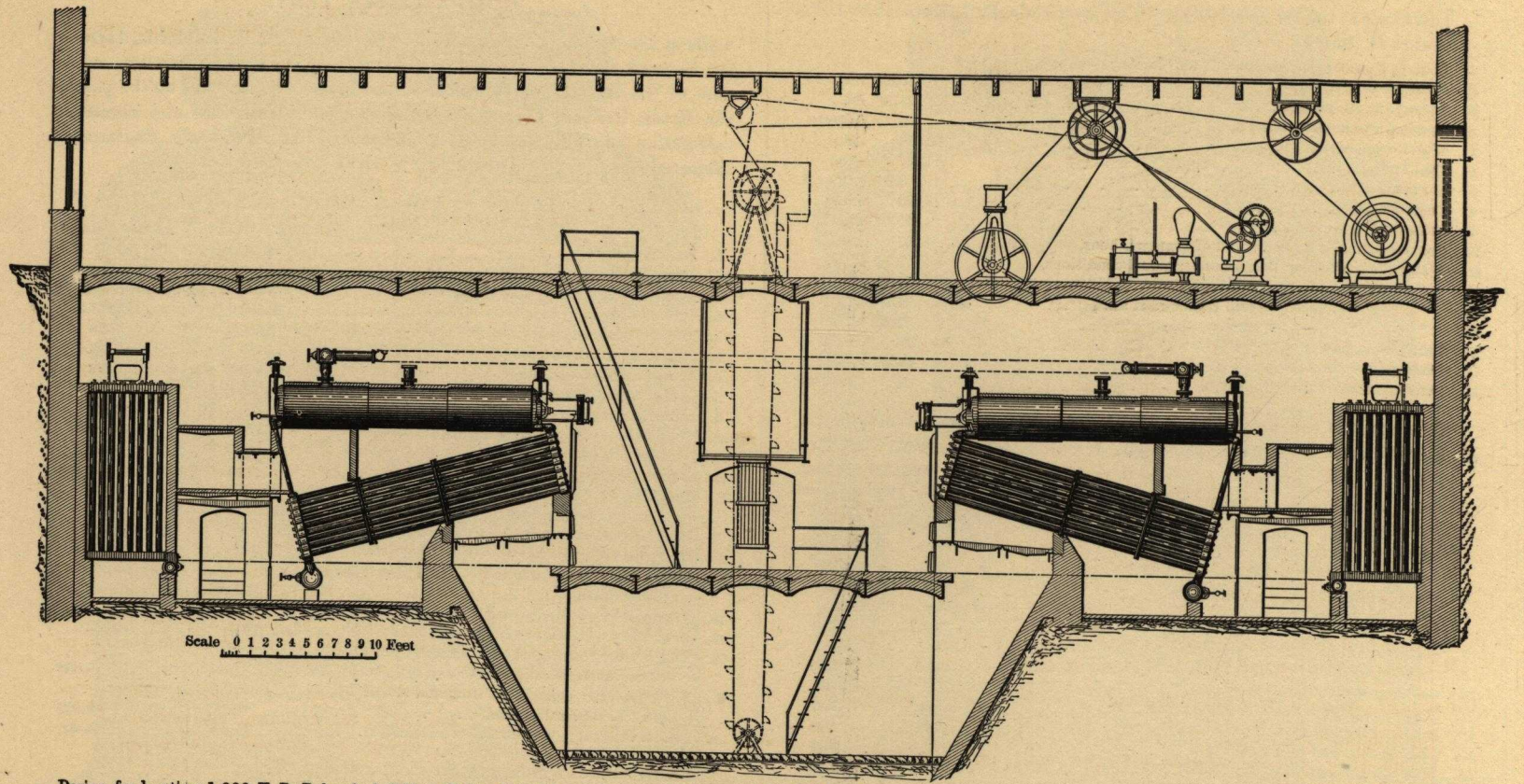
made at the station of the Brush Electric Light Co., Philadelphia, between the Babcock & Wilcox and Return Tubular boilers, by J. C. Hoadley, on the part of the Babcock & Wilcox Co., and Barnet W. Le Van, on the part of the Brush Electric Light Co., October, 1882. Full data and details of calculation of this test were published in *Van Nostrand's Engineering Magazine*, 1883, copy of which will be furnished on application.

1. TEST BY EVAPORATION OF WATER.

		Babcock & Wilcox.	*Return Tubular.*
1.	Date of test,	Oct. 18, 19, 20.	Oct. 23, 24, 25.
2.	Duration of test,	21.5 hours.	16 hours.
3.	Quality of coal (anthracite chestnut),	Wet and dirty.	Screened and dry
4.	Coal thrown on grate, lbs.	16,388.5	13,171.5
5.	Surface water in coal, "	1,207.8	378
6.	Dry coal thrown on grate, "	15,180.7	12,793.5
7.	Wood used for kindling, "	462	319
8.	Cotton waste, for starting fires, "	72.5	34.5
9.	Ashes and residue, "	3,305	2,697
10.	Combustible (in coal) consumed, "	11,875.7	10,096.5
11.	Combustible = wood × 0.36, "	166.3	115
12.	Combustible = cotton waste, "	72.5	34.5
13.	Total combustible consumed, "	12,114.5	10,246
14.	Heat units apparently received by boiler,	134,410,015	106,300,397
15.	Heat units actually received—water allowed for,	130,176,100	104,110,609
16.	Heat units received per 1 lb. of combustible,	10,745.48	10,161.1
17.	Water evaporated from and at 212° F. per 1 lb. combustible, lbs.	11.127	10.522
18.	Apparent efficiency, per cent.	74.18	70.15
19.	Heat units required to dry the coal,	1,497,793	482,555
20.	Water evaporated from and at 212° F. per 1 lb. of combustible expended in drying the coal, lbs.	0.128	0.049
21.	Water actually evaporated from and at 212° F. per 1 lb of combustible, "	**11.255**	**10.571**
22.	Actual efficiency, per cent. of theoretical,	**75.03**	**70.47**

Comparative Economy by the Evaporative Test:

$$11.255 - 10.571 = 0.684; \text{ and } \frac{0.684}{10.57} = 0.0647 = 6.47 \text{ per cent.}$$



Design for locating 1,000 H. P. Babcock & Wilcox Boilers with Economizers, and Arrangements for Handling Coal and Ashes in the Basement of a New York City Lot, 100 x 25 feet

2. TEST BY POWER DEVELOPED THROUGH ENGINES.

			Babcock & Wilcox.	*Return Tubular.*
1.	Mean indicated horse-power,		130.41	137.78
2.	Duration of experiments, as above,	hours	21.5	16
3.	Combustible consumed,	lbs.	12,114.5	10,246
4.	Combustible consumed per hour,	"	563.46	640.375
5.	Combustible consumed per H. P. per hour,	"	**4.321**	**4.648**
6.	Water evaporated,	"	130,156	104,562
7.	Water evaporated per hour,	"	6,054	6,535
8.	Water evaporated per H. P. per hour,	"	46.57	47.43
9.	Dry steam per H. P. per hour,	"	45.1	46.45
10.	Leakage per H. P. per hour,	"	10.43	12.33
11.	Dry steam *used* per H. P. per hour,	"	34.67	34.12

Comparative Economy by the Engine Test:

$$4.648 - 4.321 = 0.327; \text{ and } \frac{0.327}{4.321} = 0.0757 = 7.57 \text{ per cent.}$$

3. TEST BY WASTE HEAT IN CHIMNEY.

	Babcock & Wilcox. Parts in 100.	Return Tubular. Parts in 100.
Loss of heat carried off by heated gases in chimney	20.54	25.47
Loss by imperfect combustion, and radiation	4.43	4.06
Aggregate losses	24.97	29.53
Actual efficiency by evaporative test	75.03	70.47
Total heating power of combustible	100.00	100.00

Loss carried off by hot gases, Ret. Tub. boilers, . . 25.47 per cent.
Loss carried off by hot gases, B. & W. boilers, . . 20.54 per cent.

Difference; greater loss by Ret. Tub. boilers, . . . 4.93 per cent.

This difference, or excess of heat lost by the Ret. Tub. boilers, divided by the efficiency of these boilers (70.47 per cent.), gives the ratio of the excess of loss to actual efficiency:

$$\frac{4.93}{70.47} = 0.06996 = 7.00 \text{ per cent.}$$

4. TEST BY LIGHT.

		Babcock & Wilcox.	*Return Tubular.*
1.	Indicated horse-power, mean of all tests,	130.41	137.78
2.	Hours run,	21.5	16
3.	No. of arc lights run,	121	128.75
4.	Average H. P. per light,	1.0703	1.0701
5.	Pounds of combustible per light per hour,	4.6567	4.9738

Comparative Economy by the Light Test:

$$4.9738 - 4.6567 = 0.3171; \text{ and } \frac{0.3171}{4.6567} = 0.0681 = 6.81 \text{ per cent.}$$

4. SUMMARY OF RESULTS BY THE FOUR METHODS.

	Babcock & Wilcox.	Return Tubular.	Difference in favor of B. & W. Boilers.	Difference *per centum.*
Evaporative test	11.254	10.570	.684	6.47
Power, engine test	4.321	4.648	.327	7.57
Light test	4.6567	4.9738	.3171	6.81
Test by loss at chimney	20.54	25.44	4.9	7.00
Mean of four tests	.....	.....	.....	6.96

Explanation of Table.—The Babcock & Wilcox boilers evaporated *more* water for each pound of combustible consumed; consumed *less* combustible per hour for each indicated H.P. produced; consumed *less* combustible per hour for each arc light in use; and lost *less* heat by hot gases escaping to the chimney, than the Return Tubular boilers.

While doing this, they were evaporating 6054 pounds of water per hour, into steam, containing only 3.15 per cent. of entrained water, leaving 5863 pounds of dry steam per hour, enough at the rate of 30 pounds of dry steam per hour for each horse power to supply 195 horse power, which is 30 per cent. above their rated power.

The general result is a difference of about 7 per cent. in favor of the Babcock & Wilcox boilers, arrived at by four independent methods of comparison, all free from objection, and together, mutually confirmatory in the highest degree.

This comparison leaves out of view all disparity of coal save the ascertained difference in surface water.

STATEMENT

Concerning the Coal and other circumstances of the Tests of the Babcock & Wilcox Company's boilers, and the Return Tubular boilers, at the boiler house of the Brush Electric Light Company, near North Twentieth Street, Philadelphia.

1. The Babcock & Wilcox Company boilers, and the Return Tubular boilers being so set and connected with the steam engines which drive the dynamos, that either set of boilers can be used at pleasure to furnish steam to said engines, it was agreed that alternate tests should be made, first with the B. & W. Co. boilers, and then with the Tubular boilers, under equal and similar conditions.

2. To avoid danger of interference with the lights, it was agreed that the tests in each case should be confined to the hours from 7:30 A.M. to 2:30 P.M., when *two* of the B. & W Co. boilers, or *three* of the Return Tubular boilers could supply the necessary steam.

3. Since there was not sufficient room for the secure storage of coal at the works to store a supply for both tests, it was agreed that coal of equal quality and in equal condition was to be delivered, from the same bin at the coal yard * as required at the two sets of boilers, respectively.

4. That (owing perhaps, in part, to the wet weather prevailing during much of the week, October 16–21) the coal delivered to the B. & W. Co. boilers for the trial of these boilers, Wednesday, October 18, Thursday, October 19, and Friday, October 20, was very wet,—no less than 7.37 per cent. of water having been dried out of 100 lbs. taken from it and placed over the boilers and dried.

5. That this coal, which was of the size known as "chestnut," was unscreened, and very dirty.

6. That notwithstanding this bad condition of the coal, there was no time during the three days' trial, when steam was not kept up to the full requirements of the engines.

7. That the coal delivered for the trial of the Return Tubular boilers, on Monday, October 23, Tuesday, October 24, and Wednesday, October 25, was clean, bright, screened chestnut coal, losing only 2.87 per cent. of weight on drying, over the boilers, against 7.37 per cent. in the other case.

8. That on account of the greater load thrown on the dynamos by reason of the demand for light during the bicentennial celebration of the landing of Penn, the *three* Return Tubular boilers were not able to furnish steam for the requirements of the engines later than 2:30 P.M. on Monday, and 12:0 M. on Tuesday and Wednesday; and on this account the fires were cleaner and more efficient during the †5:0 hours run, than if the boilers had been run ‡7:0 hours each day, as was the case with the B. & W. Co. boilers.

9. That Mr. Camp's ‖ attention was called to the great disparity in quality of coal used, and he was asked (by Mr. Hoadley) to consent to another day's run of the B. & W. Co. boilers, with clean, dry, screened chestnut coal, as nearly as possible equal to that used with the Return Tubular boilers; to which request he assented provided Mr. Peifer's * consent was obtained.

10. That Mr. Le Van, who consulted Mr. Peifer on the subject, understood Mr. Peifer to assent; and to agree that Mr. Le Van and Mr. Hoadley and their assistants might select any chestnut coal in the coal yards in the vicinity, and that it should be screened, and used in a test of the B. & W. Co. boilers on Thursday, Oct. 26.

11. That Mr. Le Van and Mr. Hoadley, with Mr. Higgins † and Mr. Prentiss ‡ thereupon went to two coal yards just across the Schuylkill, where the Brush Electric Light Co. ‖ usually obtained coal, and looked and inquired for coal of the same quality as that delivered to said Brush Electric Light Co. during Monday, Tuesday and Wednesday, Oct. 23, 24 and 25, and were told that there was no similar coal in the yard. § No coal of even approximately equal quality could be found in that yard. ** In another yard near by, some fair-looking coal was found, reasonably dry, which was to be screened and sent to the works of the Brush Electric Light Co., and delivered to the B. & W. Co. boilers; and in pursuance of said agreement a certain quantity of said coal was so sent and delivered.

12. That a watch was, by Mr. Hoadley's orders, maintained all night, at the boiler house and engine room of the Brush Electric Light Co., and preparations †† were made to begin the test of the B. & W. Co. boilers with said coal at 7:30 A.M.

13. That such test was peremptorily forbidden by Mr. Peifer, and consequently could not be made, as he was in command of the boiler house, and the firemen would necessarily obey him.

14. That the test was therefore necessarily abandoned, under a joint protest by Mr. Le Van and Mr. Hoadley, who unite in the foregoing statement of facts.

(Signed,)

W. BARNET LE VAN,
J. C. HOADLEY.

(Dated,) Philadelphia, Oct. 27, 1882.

NOTE.—The several foot notes to the foregoing agreement have been appended by Mr. Hoadley, who has set his initials to them; for the purpose of correcting slight inaccuracies, and of more full explanation.

---

* Or from the same mine.—J. C. H.

† Really 7 h. 0 m. on Monday, and 4 h. 30 m. on Tuesday and Wednesday; mean, 5 h. 20 m.—J. C. H.

‡ Really 7 h. 30 m. on the 18th, and 7 h. 0 m. on the 19th and 20th; mean, 7 h. 10 m.—J. C. H.

‖ Mr. De Camp, Secretary of the Brush Electric Light Company of Philadelphia.—J. C. H.

* Engineer in charge of boilers and engines.—J. C. H.

† Assistant.—J. C. H.

‡ Assistant to Mr. Hoadley.—J. C. H.

‖ Formerly—not since June, 1882. Coal was, at the time of the experiments, obtained directly from a mine, and we were assured the clean coal used on the 23d, 24th and 25th Oct. was a special car load, and that no similar coal could be obtained in Philadelphia.—J. C. H.

§ In either yard.—J. C. H.

** The first yard visited.—J. C. H.

†† The furnaces and ashpits were cleaned out, and kindling wood was weighed and placed on the grates early in the morning. Mr. Peifer commented on the proposed run, upon the preceding night, in a manner to imply full acquiescence therein. After the kindlings were well ignited, and we were prepared to throw on weighed coal, our fireman was pushed aside, unweighed coal was, by Mr. Peifer's orders, thrown on, and the experiment thus interrupted was for bidden.—J. C. H.

CAPACITY TEST OF 250 H. P. OF BABCOCK & WILCOX BOILERS AT AMERICAN INSTITUTE FAIR.

NEW YORK, Jan. 20, 1883.

Benj. R. Western, Esq., Chairman of Committee, Am. Institute Fair:

SIR,—In accordance with your instructions, we have made an evaporative test of the Babcock & Wilcox boilers now in the American Institute building.

Upon examination of the premises we found that there were no proper facilities for making the test, and, therefore, had to make the needful preparations, which were to clean the boilers and furnaces and flues thoroughly; cement up all cracks in the masonry; setting of the boilers; prepare two weighing tanks and scales, for weighing the water as fed to the boilers, and a scale for weighing the coal as delivered to the boilers.

The water supplied was taken from the Croton, and, from frequent trials by the thermometer, was found at no time to differ but a small fraction from 36 degrees Fahr. We have, therefore, taken 36 degrees as the temperature of the water supplied to the boilers. The water was fed to the boilers by a steam pump (after weighing), hence was sent into the boilers without any change of temperature.

The coal used was No. 1 chestnut, of fair quality, supplied from a neighboring coal-yard, and was not selected, or even examined by us until delivered at the building.

Two firemen only were employed during the whole test of 15 hours. They were evidently experienced firemen, and the firing was done well throughout the test. The test was commenced at 2:40 P.M. on January 13, and terminated at 5:40 A.M. on January 14, a period of 15 hours.

On the day previous to commencing the test (Jan. 12) the boilers were filled, steam raised, and apparatus for the work tried, to see that all was in proper condition, and during the night banked fires were kept under the boilers. On the morning of January 13 the boilers were again fired up, and a short time previous to commencing the test the fires were thoroughly cleaned and leveled off, and brought to active condition, and the height of water noted when the test was commenced. At the close of the test the water was at the same height in the boilers, and the fires judged to be in the same condition as at the commencement.

The evaporation was under atmospheric pressure and temperature, and, to avoid any error from priming or water being carried off mechanically with the steam, large tanks of wood were constructed for the escape of steam. There were two openings of five inches diameter from each boiler to these tanks, so that there was no perceptible current. Provision was made to carry from the wood trunks any water condensation through a drip pipe, so that none should be returned to the boilers to be evaporated a second time, and the very slight drip from this pipe (mere drops) was conclusive evidence that the boilers were giving off essentially "dry" steam. As respects the evaporative power of the boilers, the following are the observed data:

Temperature of feed water,		36° Fahr.
Temperature of evaporation,	From and at	212 degrees
Total quantity of coal consumed in the 15 hours,		16,509 lbs.
Total quantity of water evaporated in 15 hours from 36° F.,		123,146 "
Grate-surface of the two boilers,		70 sq. ft.
Heating-surface of the two boilers,		2,807 "

From this follows that the evaporation per hour, $\frac{123146}{15}$, was 8,209.8 lbs. from 36° Fahr., or 9,710.5 lbs. from and at 212 degrees Fahr.

The generally accepted unit for one horse power is the evaporation of 30 lbs. of water per hour, from and at 212° Fahr. Accepting this unit, the power of these boilers would be $\frac{9710 \cdot 5}{30} = 323.68$ **horses**; but taking the unit as 30 lbs. evaporated per hour from the temperature of the feed water (in this case 36° Fahr.), the power would then be $\frac{8209 \cdot 8}{30} = 273.66$ horse power.

The evaporative power of the boilers was what we were directed to ascertain; but, in addition, the following will show the economy of evaporation under the existing conditions: the total amount of coal consumed in the 15 hours was 16,509 lbs., and weight of water evaporated from 36 degrees Fahr. by one pound of coal $= \frac{123146}{16509} = 7.46$ lbs., and the evaporation from and at 212 degrees 8.82 lbs. for 1 lb. of coal. The weight of coal consumed per hour was $\frac{16509}{15} = 1100.6$ lbs., or $\frac{1100 \cdot 6}{70} = 15.72$ lbs. per square foot of grate, and $\frac{1100 \cdot 6}{2807} = .392$ lbs. per square foot of heating surface.

In this statement of coal consumption no deduction whatever has been made for ashes or clinkers, but the total weight of coal thrown into the furnaces is charged.

(Signed,) Very respectfully, CHAS. W. COPELAND, M. E.
RICHARD H. BUEL, M. E.

Test made at Harrison, Havemeyer & Co., Franklin Sugar Refinery, Philadelphia, Pa., by C. A. Brinley, Chief Engineer.

Being the result of four separate runs of 72 hours each, in Oct., 1883, and April and May, 1884, on regular work, with "Buckwheat" Anthracite coal from different mines.

1.	Duration of test (Boilers had been in constant use for five years)	288	hours.
2.	Average steam pressure,	73.52	lbs.
3.	Average temperature of feed water in tank,	82.195	degrees.
4.	Pounds of coal burned,	216,987.8	lbs.
5.	Pounds of combustible,	179,295.3	"
6.	Per cent. of ash,	17.41	per cent.
7.	Coal burned per square foot grate per hour,	14.685	lbs.
8.	Total water evaporated at temperature of feed,	1,765,926.	"
9.	Water evaporated per lb. coal—actual conditions,	8.124	"
10.	" " " " —from and at 212°,	9.49	"
11.	" " " combustible actual conditions,	9.833	"
12.	" " " " from and at 212°,	**11.485**	"
13.	Quality of steam—13 tests, moisture,	1.28	per cent.
14.	Rated horse-power,	187.	H. P.
15.	Horse-power developed from feed at 212° and 70 lbs. pressure,	231.61	H. P.
16.	Per cent. above rated capacity,	23.72	per cent.
17.	Temperature of flue gases,	455.	degrees.

Test made at the American Grape Sugar Co., Buffalo, N. Y., January 20, 1885, on boiler erected in July, 1878, by Edwin Roat, Chief Engineer.

1.	Bituminous coal.		
2.	Duration of test,	10	hours.
3.	Average steam preassure,	68.97	lbs.
4.	Average temperature of feed water entering boiler,	121.42	degrees.
5.	Pounds of coal burned,	15,065	lbs.
6.	Pounds of combustible,	13,700	"
7.	Per cent. of ash,	9.06	per cent.
8.	Coal burned per square foot grate per hour,	15	lbs.
9.	Total water evaporated at temperature of feed,	143,683	"
10.	Water evaporated per square foot heating surface per hour,	4.11	"
11.	" " " lb. coal—actual conditions,	9.53	"
12.	" " " " " —from and at 212°,	10.88	"
13.	" " " " combustible actual conditions,	10.48	"
14.	" " " " " from and at 212°,	**11.97**	"
15.	Rated horse-power,	300	H. P.
16.	Horse-power developed from feed at 212° and 70 lbs. pressure,	529.4	H. P.
17.	Per cent. above rated capacity,	76.4	per cent.

Test made at Benedict & Burnham Manuf'g Co., Waterbury, Conn., Mar. 17 and 18, 1883, by Wm. E. Crane, their engineer.

1.	Coal, anthracite egg.		
2.	Duration of test,	22	hours.
3.	Average steam pressure,	60	lbs.
4.	Average temperature of feed water entering boiler,	36	degrees.
5.	Pounds of coal burned,	21,400	lbs.
6.	Pounds of combustible,	18,626	"
7.	Per cent of ash,	12.9	per cent.
8.	Coal burned per square foot grate per hour,	16.21	lbs.
9.	Total water evaporated at temperature of feed,	175,579	"
10.	Water evaporated per lb. coal—actual conditions,	8.20	"
11.	" " " " —from and at 212°,	9.93	"
12.	" " " combustible actual conditions,	9.42	"
13.	" " " " from and at 212°,	**11.41**	"
14.	Quality of steam, (moisture),	1.81	per cent.
15.	Rated horse-power,	250	H. P.
16.	Horse-power developed,	312.12	"
17.	Per cent. above rated capacity,	24.8	per cent.

Test made at Messrs. Hepburn & Co's Grant Mills, Ramsbottom, Scotland, July 24th, 1884, by Messrs. Hepburn & Co.

Babcock & Wilcox Co's Boiler, with the patent regenerative furnace, with dross "Pick-up" @ 4/9d. and "Crosses" at 5/3d., mixed to equal parts. Cost to evaporate 1000 lbs. water into steam @ 70 lbs. pressure, 2.82 pence, sterling.

1.	Duration of test,	8	hours.
2.	Average steam pressure, by gauge,	50	lbs.
3.	Average temperature of feed water entering boiler,	208	degrees
4.	Pounds of coal burned,	5,824	lbs.
5.	Pounds of refuse,	630	"
6.	Pounds of combustible,	5,194	"
7.	Per cent. of ash,	11	per cent.
8.	Coal burned per square foot grate per hour,	24.26	lbs.
9.	Total water evaporated at temperature of feed,	55,300	"
10.	Water evaporated per lb. coal—actual conditions	9.497	"
11.	" " " " " —from and at 212°,	10.627	"
12.	" " " " combustible actual conditions,	9.826	"
13.	" " " " " from and at 212°,	**10.998**	"
14.	Rated horse-power	136	H. P.
15.	Horse-power developed from feed at 212° and 70 lbs. pressure,	232.2	H. P.
16.	Per cent. above rated capacity	70.7	per cent.

Test of four Babcock & Wilcox boilers at the Arlington Mills M'f'g Co's, Wilmington, Del., May 9, 1883, by Geo. H. Barrus, M. E.

1.	Coal, anthracite pea, Sterling Mine, Shamokin Region, Pa.		
2.	Duration of test,	11	hours.
3.	Average steam pressure,	106.2	lbs.
4.	Average temperature of feed,	145.3	degrees.
5.	Water evaporated,	161,656	lbs.
6.	Coal fired,	19,043	"
7.	Per cent. of ash,	17.4	per cent.
8.	Combustible,	15,726	lbs.
9.	Grate-surface,	141.68	sq. ft.
10.	Coal consumed per square foot of grate per hour,	12.22	lbs.
11.	Water evap. per lb. coal under actual conditions,	8.49	"
12.	" " " combustible " "	10.28	"
13.	" " " coal from and at 212°,	9.13	"
14.	" " " combustible " "	**11.44**	"
15.	Rated horse-power,	488	H. P.
16.	Horse-power developed from 212° feed and 70 lbs. steam,	526	"
17.	Per cent. above rated capacity,	7.7	per cent.

Test of three Babcock & Wilcox boilers at the Arlington Mills M'f'g Co's, Wilmington, Del., May 10, 1883, by Geo. H. Barrus, M. E.

1.	Coal, anthracite pea, Sterling Mine, Shamokin, Pa.		
2.	Duration of test,	11	hours.
3.	Average steam pressure,	105.4	lbs.
4.	Average temperature of feed,	156.7	degrees.
5.	Water evaporated,	155,767	lbs.
6.	Coal fired,	18,371	"
7.	Per cent. of ash,	15.8	per cent.
8.	Combustible,	15,470	lbs.
9.	Grate-surface,	106.26	sq. ft.
10.	Coal consumed per square foot of grate per hour,	15.72	lbs.
11.	Water evap. per lb. coal under actual conditions,	8.48	"
12.	" " " combustible " "	10.07	"
13.	" " " coal from and at 212°,	9.01	"
14.	" " " combustible " "	**11.08**	"
15.	Rated horse-power,	366	H. P.
16.	Horse-power developed from 212° feed and 70 lbs. steam,	502.1	"
17.	Per cent. above rated capacity,	37.1	per cent.

AVERAGE RESULTS OF TESTS.

The following table gives the average results of the foregoing tests; and as they were made in widely separated places, with all classes of fuel, by well-known engineers, they may be taken as a fair showing of the results which may be obtained by Babcock & Wilcox Boilers in regular practice.

	Test.	Engineer making Test.	Rated H. P.	H. P. actually developed.	Pounds of coal burned per sq. foot grate.	Water per lb. combustible from and at 212°	Water from and at 212° per sq. foot H. S.
1.	Raritan Woolen Mills	Chas. E. Emery	360	464	14.84	11.221	3.78
2	Oliver Wire Works	Wm. Kent	416	522.84	24 14	10.909	3 54
3.	Mill Creek Distillery	J. W. Hill	240	418.7	27.5	10.997	4.52
4.	McEachran, Adams & Co.	Chas. A. Knight	122	129	13 44	12.38	2.00
5.	Edison Co., (London)	F. A. Fleming.	146	119.9	6.26	12.46	1.70
6	Miami Soap Works	J. W. Hill	146	249.69	14.77	9.23	4.48
7.	Edison Co., (Menlo Park)	Chas. L. Clarke	75	83	9.3	11.36	2 85
8.	Harrison, Havemeyer & Co.	Peter Ehlers	190	220	12.99	11.6	3.02
9.	Peacedale M'f'g Co	Geo. H. Barrus	284	447.7	20	12.42	4.81
10.	Genesee Mills	A. Worthington	136	186.1	28.2	11.12	3.45
11.	" "	A. Worthington	136	173.5	25.6	11.84	3.36
12.	" "	A. Worthington	136	182.3	28.9	10.42	3.52
13.	Brush Electric Light Co.	J. C. Hoadley	150	195	15.6	11.255	3.98
14.	American Institute Fair	Chas. W. Copeland	250	323.68	15.73		3.45
15.	Arlington Mills	Geo. H. Barrus	488	526	12.22	11.44	2.81
16.	" "	Geo. H. Barrus	366	502.1	15.72	11.08	3.57
17.	Harrison, Havemeyer & Co.	C. A. Brinley	187	231.61	14.685	11.485	2.85
18.	American Grape Sugar Co.	Edwin Roat	300	529.4	15	11.97	4.11
19.	Benedict & Burnham Co.	Wm. E. Crane	250	312.12	16.21	11.41	2.88
20.	Hepburn & Co	Hepburn & Co	136	23 22	24.26	10.998	4.40
	Totals		4514	6048.84			
	Averages		**34.5** per ct. above rated.		15.396	**11.292**	**3.71**

The above shows that in twenty tests, during which over **3000 tons of water** were actually evaporated with a great variety of coals, the boilers exerted **34½ per cent.** more than their rated power, and gave an **average** evaporation of **11.292** pounds of water from 212° made into steam at atmospheric pressure, for each pound of combustible. The average evaporation per hour per square foot of surface, was 3.71 lbs. water, requiring but 8.08 square feet of heating-surface per actual horse-power developed.

AWARDS.

[No. 235.]

INTERNATIONAL EXHIBITION,

PHILADELPHIA, 1876.

THE United States Centennial Commission has examined the report of the judges, and accepted the following reasons, and decreed an award in conformity therewith.

PHILADELPHIA, March 2, 1877.

REPORT ON AWARDS.—Product, **Sectional Safety Steam Boiler**; name and address of exhibitor, **Babcock & Wilcox,** New York, N. Y. The undersigned, having examined the product herein described, respectfully recommends the same to the United States Centennial Commission for Award, for the following reasons, viz: The steam boiler exhibited, being of the class of the so-called sectional boilers, is in all parts very well accessible, allowing well the repair of a tube, when damaged. It gives the heated water a free circulation, and to the steam generated in the tubes clear passage to the steam room. Also it allows free expansion to the parts exposed to the greatest heat. F. REULEAUX, *Judge.*

Approval of Group Judges.

CHARLES T. PORTER, EMIL BRUGSCH, JOSEPH BELKNAP,
CHAS. E. EMERY, HORATIO ALLEN.

[SEAL.]

A true copy of the record.

FRANCIS A. WALKER,
Chief of the Bureau of Awards.

Given by authority of the United States Centennial Commission.

A. T. GOSHORN, *Director-General.*

J. L. CAMPBELL, *Secretary.* J. R. HAWLEY, *President.*

INTERNATIONAL COTTON EXPOSITION,

ATLANTA, GEORGIA.

THE Executive Committee of the International Cotton Exposition has examined and accepted the following report of the Judges, and decreed an award in conformity therewith:

ATLANTA, GEORGIA, December 31, 1881

[Group No. 9, Class 43, Entry 504.]

REPORT ON AWARDS.

Product, STEAM BOILERS AND FURNACE; *Name and address of Exhibitor,* THE BABCOCK & WILCOX CO., New York.

The undersigned having examined the product herein described, respectfully recommend the same to the Executive Committee for award, for the following reasons, viz:

Rapid generator of steam, safety from danger of explosion; thorough combustion of fuel and smoke, large draught and dryness of steam furnished; accessibility, durability, capacity, freedom from rusting by exposure, and ease of transportation of parts. Also for economy of fuel per pound of water converted into steam, as has already been thoroughly demonstrated. This furnace is of novel construction, and seems to the Judges to be fitted for the combustion of Bituminous coal. The gases from the coal as fed on the upper set of grate bars, appear to be thoroughly consumed while passing over the rear or lower set.

SAM'L WEBBER,
Signature of the Judge.

Approval of Group Judges:

F. H. UNDERWOOD,

J. W. ROBERTSON.

Given by the authority of the Executive Committee of the International Cotton Exposition. A true copy of the record.

[SEAL.]

J. K. LEWIS,
Secretary pro tem.

H. I. KIMBALL,
Director General.

REFERENCES FOR BABCOCK & WILCOX BOILERS.

The following parties are among those to whom we have sold boilers in the past fifteen years. We would call particular attention to the numerous instances in which repeated orders have been given after years of use. This single fact tells more than volumes of certificates.

SUGARS.

			Boilers.	*H. P.*
BROOKLYN SUGAR REFINING CO., Brooklyn, N. Y.	1st order,	Jan., 1876,	16	3464
do do do	4th do	Oct., 1884,		
DECASTRO & DONNER Sugar Ref'g Co., do	1st do	Aug., 1871,	19	2880
do do do	7th do	Feb., 1881,		
HAVEMEYER SUGAR REFINING CO., do	1st do	May, 1871,	14	2420
do do do	5th do	May, 1883,		
HAVEMEYERS & ELDER, Sugar Ref'g Co., do	1st do	Sept., 1871,	8	600
do do	2d do	May, 1872,		
MATTHIESSEN & WIECHERS S. R. Co., Jersey City,	1st do	Oct., 1871,	21	5198
do do	8th do	Jan., 1886,		
HARRISON, FRAZIER & CO., Philadelphia, Pa.,	1st do	Dec., 1871,	32	6218
do do	9th do	Mar., 1886,		
E. C. KNIGHT & CO., Philadelphia, Pa.,	1st do	Sept., 1880,	8	1980
do do	3d do	Mar., 1887,		
PENNSYLVANIA SUGAR REFINING CO., Philadelphia, Pa.,		Oct., 1881,	2	250
GROCERS' SUGAR HOUSE, Philadelphia, Pa.,		Oct., 1881,	2	250
BOSTON SUGAR REFINERY, East Boston, Mass.,	1st order,	Mar., 1880,	5	1250
do do	2d do	May, 1881,		
BAY STATE SUGAR REFINERY, Boston, Mass ,	1st do	Sept., 1880,	9	1758
do do	3d do	Nov., 1887,		
STANDARD SUGAR REFINERY, Boston, Mass..		Nov., 1880,	2	500
FOREST CITY SUGAR REFINING CO., Portland, Me.,	1st do	Nov., 1881,	5	700
do do do	2d do	Feb., 1887,		
AMERICAN GLUCOSE CO., Buffalo, N. Y., Works A,	1st do	May, 1879,	13	3050
do do do	4th do	Jan., 1882,		
do Peoria, Ill., Works P,	1st do	Mar., 1880,	8	1960
do do do	2d do	June, 1888,		
do Leavenworth, Kan., Works L,	1st do	Sept., 1882,	4	500
CHICAGO SUGAR REFINING CO., Chicago, Ill.,	1st do	Sept., 1880,	15	2846
do do do	2d do	Sept., 1887,		
ROCKFORD GRAPE SUGAR CO., Rockford, Ill.,		May, 1882,	2	300
BELCHER SUGAR REFINING CO., St. Louis, Mo.,	1st do	Nov., 1872,	9	1925
do do do	2d do	Dec., 1881,		
KANSAS CITY GRAPE SUGAR CO., Kansas City, Mo.,		May, 1883,	2	292
ST. JOSEPH SUGAR REFINERY, St. Joseph, Mo.,	1st do	Aug., 1880,	4	535
do do do	2d do	Sept., 1881,		
FIRMINICH MFG. CO., Marshalltown, Ia.	1st do	July, 1880,	8	1250
do do	2d do	April, 1882,		
FLORIDA SUGAR REFINING CO., St. Cloud, Fla.,	1st do	Nov., 1887,	5	738
do do do do do	2d do	June, 1888,		
LOUISIANA SUGAR REF'G CO., New Orleans, La.,	1st do	Mar., 1883,	6	1440
do do	4th do	April, 1888,		
PLANTERS' SUGAR REFINERY, New Orleans, La.,	1st do	June, 1882,	3	532
do do do do	2d do	May, 1888,		

			Boilers.	*H. P.*
NORTH BEND PLANTATION, near Centreville, La.,	1st do	Mar., 1879,	4	400
do do	2d do	Nov., 1879,		
D. F. KENNER, Plantation, Hermitage, La.,		May, 1881,	2	258
FOOS & BARNETT, Plantation, Centreville, La.,		July, 1881,	1	120
R. H. YALE, Ascension Parish, La.,		April, 1883,	2	244
WM. H. BALLARD, Chatham Plantation, Ascension Parish, La.,		Mar., 1883,	2	208
JNO. CROSSLEY & SONS, Ld., Southwood Plantation, Ascension Parish, La.,		4 orders, 1883—1886,	8	1510
JNO. CROSSLEY & SONS, Ld., Mt. Houmas Plantation, Ascension Parish, La.,		2 orders, 1883—1886,		
J. H. PUTNAM, Rose Hill Plantation, Abbeville, La ,		April, 1883,	1	122
SCHMIDT & ZIEGLER, Willswood Plantation, New Orleans, La.,		June, 1886,	2	328
WELHAM ESTATE, St. James Parish, La.,	1st do	June, 1886,	3	636
do do do	2d do	May, 1888,		
NOVA SCOTIA SUGAR REFINERY, Halifax, N. S.,	1st order,	April, 1880,	8	808
do do do	2d do	Aug., 1884,		
MONCTON SUGAR REFINING CO., Moncton, N. B.,	1st do	July, 1880,	3	456
do do do	2d do	June, 1885,		
REFINERIA DE AZUCAR DE CARDENAS, Cuba,	1st do	May, 1883,	17	2177
do do do do	6th do	June, 1886,		
Yngenio "UNION," Cuevitas, Cuba,	1st do	Aug , 1879,	8	1100
do do do	4th do	Aug., 1886,		
Yngenio "SAN RAMON," Manzanillo, Cuba,	1st do	Aug., 1882,	3	312
do do do	2d do	Feb., 1883,		
Yngenio "CENTRAL YSABEL," Media Luna, Manzanillo, Cuba,		April, 1886,	8	976
Yngenio "SANTA ROSA," Guantanamo, Cuba,		July, 1881,	1	150
Yngenio "SAN ANTONIO," do do	1st order,	July, 1881,	3	442
do do do do	2d do	Feb., 1883,		
Yngenio "SOLEDAD," do do	1st do	May, 1880,	4	281
do do do do	3d do	June, 1888,		
Yngenio "LOS CAÑOS," do do	1st do	Mar., 1883,	4	305
do do do do	2d do	Oct., 1884,		
Yngenio "SAN JOSE," do do		May, 1881,	4	300
Yngenio "SAN VINCENTE," do do		Aug., 1885,	2	164
Yngenio "SANTA MARIA," do do	1st do	June, 1882,	3	221
do do do do	3d do	July, 1885,		
Yngenio "SANTA FE," do do		July, 1883,	1	146
Yngenio "BELLEZA," Santiago, Cuba,		May, 1881,	2	150
Yngenio "SAN SEBASTIAN," Santiago, Cuba,	1st do	Sept., 1884,	2	164
do do do	2d do	Feb., 1886,		
Yngenio "HORMIGUERO," Palmira, Cuba,	1st do	Aug., 1881,	4	300
do do do	2d do	Aug., 1882,		
Yngenio "CONSTANCIA," Cienfuegos, Cuba,	1st do	Oct., 1881,	17	2264
do do do	6th do	Aug., 1887,		
Yngenio "LEQUEITIO," do	1st do	Sept., 1887,	5	649
do do do	3d do	Jan., 1888,		

			Boilers.	H. P.
Yngenio "SAN LINO," do		Nov., 1887,	2	292
Yngenio "CIENEGUITA," Abreus, Cuba,	1st do	April, 1882,	3	450
do do do	2d do	June, 1888,		
Yngenio "CENTRAL REDENCION," Nuevitas, Cuba,		Jan., 1883,	2	146
Yngenio "LA CARIDAD," do		June, 1883,	2	240
Yngenio "EL CONGRESO," do	1st do	June, 1883,	7	1228
do do do	7th do	Aug., 1885,		
Yngenio "SENADO," Nuevitas, Cuba,	1st do	July, 1883,	4	790
do do do	3d do	Sept., 1886,		
Yngenio "GRATITUD," Manacas, Cuba,		Aug., 1883,	2	208
Yngenio "FORTUNA," Alquizar, Cuba,		July, 1883,	6	624
Yngenio "SAN LUCIANO," Macagua, Cuba,		July, 1884,	2	208
Yngenio "SAN CLAUDIO," Cabañas. Cuba,	1st order,	July, 1884,	5	615
do do do	2d do	April, 1885,		
Yngenio "SANTA CATALINA," Corral Falso, Cuba,	1st do	Mar., 1885,	5	520
do do do do	3d do	Sept., 1886,		
Yngenio "SANTA FILOMENA," do do		June, 1885.	4	416
Yngenio "SANTA RITA," Baro, Cuba,		Jan., 1886,	2	208
Yngenio "SAN JOAQUIN," Pedroso, Cuba,		Aug., 1884,	2	208
Yngenio "NTRA. SRA. DEL CARMEN," Matanzas, Cuba,		Jan., 1886,	1	146
Yngenio "TERESA," Cruces, Cuba,	1st order,	April, 1884,	4	416
do do do	2d do	Oct., 1885,		
Yngenio "EMILIA," Güines, Cuba,	1st do	Dec., 1884,	3	386
do do do	2d do	Aug., 1885,		
Yngenio "SOCORRO," Corralillo, Cuba,		May, 1885,	2	292
Yngenio "SANTA ISABEL," Sagua, Cuba,		Sept., 1885,	1	104
Yngenio "ASUNCION," Mariel, Cuba,		July, 1885,	2	208
Yngenio "DOS AMIGOS," Campechuela, Cuba,	1st order,	Sept., 1885,	4	416
do do do	2d do	Sept., 1886,		
Yngenio "CAÑAMABO," Trinidad, Cuba,		Sept., 1885,	2	292
Yngenio "SANTA GERTRUDES," Banaguises, Cuba,	1st do	Aug., 1885,	3	438
do do do	2d do	June, 1887,		
Yngenio "SAN AUGUSTIN," Quibian, Cuba,		Aug., 1886,	1	140
Yngenio "MI ROSA," do		Oct., 1886,	2	300
Yngenio "SAN FERNANDO," St. Spiritus, Cuba,		Oct., 1886,	1	104
Yngenio "SANTA TERESA," Ceiba Hueca, W. I.,		Jan., 1886,	1	208
Yngenio "ANGELINA," San Domingo, W. I.,		Aug., 1879,	1	75
Hacienda "FORTUNA," Porto Rico,		Nov., 1883,	1	104
Hacienda "FLORIDA YANCO," Porto Rico,		Jan., 1884,	1	104
Hacienda "REPARADA," do		Feb., 1885,	1	104
Hacienda "LOS CAÑOS," do		Sept., 1886,	1	104
Hacienda "GUARACHA," Irapuato, Mexico,		Aug., 1884,	1	122
Hacienda "SAN MARCOS," Jalisco, do	1st order,	Jan., 1884,	4	244
do do do do	2d do	Oct., 1885,		
PUGA SUGAR REFINERY, Tepic, Puebla, Mexico,		Nov., 1883,	1	104
GARCIA ICAZBALCETA HERMANOS, City of Mexico,	2 orders,	Nov., 1887,	2	184
INGENIO "VICTORIA EN GRECIA," Costa Rica,		Mar., 1886,	1	51
SAY ET CIE, Paris, France,		Nov., 1886,	1	130
BERNARD NEVEUX, Santes, France,		May, 1887,	1	240
SALA PON & CO., Barcelona, Spain,	1st do	Apr., 1887,	2	208
do do do	2d do	Jan., 1888,		
LA REFINERIA Barcelona, Spain.		Feb., 1888,	2	208
SOCIETA ANONIMA RAFFINERIA DI ZUCCHERI, Ancona, Italy,		Apr., 1886,	3	360
LEE YEUN SUGAR REFINING CO., Hong Kong, China,		Sept., 1883,	1	104

			Boilers.	H. P.
RECIPROCITY SUGAR CO., Hana, Maui, Hawaiian Islands,		Nov., 1883,	1	122
HAWAIIAN AGRICULTURAL CO., Pahala, do	1st order,	Jan., 1886,	3	490
do do do do	2d do	Feb., 1886,		

TEXTILE MANUFACTURERS.

COTTON.

LOCKWOOD CO., Waterville, Me.,		June, 1881,	2	309
COCHECO MFG. CO., Dover, N. H.,		July, 1881,	2	164
JOEL H. GATES & CO., Burlington, Vt.,		Mar., 1883,	2	244
ARLINGTON MILLS, Lawrence, Mass.,		Feb., 1887,	12	2880
BARNABY MFG. CO., Fall River, Mass.,		Mar., 1882,	4	448
HEBRON MFG. CO., Attleboro, Mass.,		Mar., 1882,	4	400
MANCHAUG CO., Manchaug, Mass.,		June, 1882,	4	400
HADLEY CO., Thread, Holyoke, Mass.,	1st order	June, 1883,	2	197
do do do	2d do	June, 1886,		
B. B. & R. KNIGHT, Providence & Natick, R. I.,	1st do	Feb., 1884,	8	1710
do do do	4th do	Dec., 1886,		
NOTTINGHAM MILLS, Providence, R. I.,	1st do	Oct., 1884,	4	416
do do do	2d do	Jan., 1885,		
PEACEDALE MFG. CO., Peacedale, R. I.,		July, 1882,	2	280
CUTLER MFG. CO., Yarn and Cotton Cordage, Warren, R. I.,		Jan., 1883,	1	92
PALMER BROS., Montville, Conn.,	1st do	May, 1879,	2	120
do do	2d do	May, 1882,		
FALLS COMPANY, Norwich, Conn.,	1st do	July, 1881,	4	368
do do do	3d do	June, 1882,		
PONEMAH MILLS, Taftville, Norwich, Conn.,	1st do	Sept. 1882,	4	400
do do do do	2d do	Oct. 1883,		
QUINNEBAUG CO., Danielsonville, Conn.,	1st do	Aug., 1882,	5	518
do do	2d do	Oct., 1883,		
WHITE MANUFACTURING CO., Rockville, Conn.,		June, 1887,	1	136
ONECO MFG. CO., New London, Conn.,		June, 1888,	2	208
IRVING MFG. CO., New Brighton, S. I., N. Y.,		Sept, 1883,	1	92
T. H. SMITH, Jamestown Cotton Mill, Jamestown, N. Y.,		Sept., 1880,	2	160
HARDER KNITTING CO., Hudson, N. Y.,		Jan., 1882,	2	150
MILLVILLE MFG. CO., Millville, N. J.,		Oct., 1881,	1	104
HENRY McKEEN & CO., S. Easton, Pa.,		Mar., 1882,	1	50
ARLINGTON MILLS MFG. CO., Wilmington, Del.,		Aug., 1880,	4	500
MT. VERNON MILLS, Baltimore, Md.,		Mar., 1882,	4	500
W. H. BALDWIN, Jr., & Co., Savage, Md.,		Aug., 1881,	2	500
RANDELMAN MFG. CO., Randelman, N. C.,		Aug., 1887,	1	51
F. & H. FRIES, Salem, N. C.,	1st do	Aug., 1880,	2	250
do do	2d do	April, 1881,		
CHARLOTTE COTTON MILLS, Charlotte, N. C.,	1st do	June, 1884,	4	301
do do	2d do	Dec., 1886,		
GASTONIA COTTON MFG. CO., Gastonia, N. C.,		Feb., 1888,	1	82
HUGUENOT MILLS, Greenville, S. C.,	1st do	Mar., 1882,	2	100
do do do	2d do	June, 1886,		
SUMTER COTTON MILLS, Sumter, S. C.,		Jan. 1881,	1	75
J. J. DALE & CO., St. Helena Island, S. C.,		June, 1880,	1	50
NEWBERRY COTTON MILLS, Newberry, S. C.,	1st do	Sept., 1883,	3	480
do do do do	2d do	April, 1887,		
REEDY RIVER MFG. CO., Reedy River Factory, S. C.,		Jan., 1884,	1	51

			Boilers.	H. P.
DARLINGTON MILLS, Darlington, S. C.,		April, 1884,	2	272
THE SWIFT MFG. CO., Columbus, Ga.,	1st do	Mar., 1883,	5	511
do do do	3d do	May, 1887,		
EXPOSITION COTTON MILL, Atlanta, Ga.,		Feb., 1882,	2	208
FULTON COTTON SPINNING CO., Atlanta, Ga.,	1st do	April, 1881,	4	602
do do do do	3d do	Oct., 1886,		
BIBB MFG. CO., Macon, Ga.		Nov., 1887,	1	208
MADISON COTTON GINNING CO., Madison, Fla.,		July, 1882,	1	60
ADAMS COTTON MILLS, Montgomery, Ala.,	1st do	Oct., 1881,	2	117
do do do	2d do	— 1887,		
MAGINNIS COTTON MILL, New Orleans, La.,	1st do	Feb., 1882,	9	1344
do do do do	3d do	July, 1888,		
FLINT COTTON & WOOLEN MFG. CO., Flint, Mich.,		Aug., 1881,	1	82
S. B. WILKINS CO., Rockford, Ill.,	1st do	May, 1881,	2	121
do do	2d do	Sept., 1887,		
CALIFORNIA COTTON MILLS, Oakland, Cal.,		Jan., 1884,	2	208
MONCTON COTTON MFG. CO., Moncton, N. B.,		Sept., 1882,	2	300
WALTER CRUM & CO., Thornliebank, Scotland,		Feb , 1883,	1	122
THOMSON & ROBERTSON, Milngavie, Scotland,		July, 1883,	1	122
F. STEWART SANDEMAN, Stanley, Scotland,		Aug., 1883,	1	55
JOSEPH SCHOFIELD & CO., Littleborough, Lanc., Eng.,		Mar., 1885,	1	136
HARTFORD MILLS CO., Preston, England,		Sept., 1885,	1	156
PADIHAM SPINNING CO., Padiham, England,		Aug., 1885,	1	156
PENDLEBURY & SONS, Radcliffe, England,		Feb., 1886,	1	156
R. & H. HINCHCLIFFE, Mytholanroyd, York, England.		Sept., 1886,	1	156
THE OAK MOUNT SPINNING & MFG. CO., Burnley, Eng.,		May. 1887,	1	124
BOTTERIL, POTTER & CO., Finishers, Bradford, England,		May, 1888,	1	124
THE PLATT LANE MFG. CO., L't'd, Hindley, England,		April, 1888,	1	124
FERDINAND BRACQ, Spinner, Ghent, Belguim,		May, 1888,	1	105
WIBAUX MOTTE, Roubaix, France,		May, 1885,	2	184
ALLART ROUSSEAU, Cardar, Roubaix, France,		Sept., 1885,	4	744
A. PROUVOST & CO., Carders, Roubaix, France,		Oct., 1885,	3	558
WIBAUX FLORIN, Twister, Roubaix, France,	1st do	April, 1885,	4	544
do do do	2d do	Oct., 1885,		
A. DELADALLE, Roubaix, France,		Oct., 1885,	1	186
M. PATTYN, Spinner, Roubaix, France,		Dec., 1885,	1	123
C. & J. POLLET, Roubaix, France,		Feb., 1887,	1	186
M. COSSERAT, Weaver, Amiens, France,	1st do	May, 1885,	3	252
do do	3d do	Aug., 1887,		
VINCENT PONNIER & CO., Sonones, Vosges, France,	1st do	May, 1885.	2	159
do do Moussey, France,	2d do	July, 1885,		
FLIPO FRERES, Tourcoing, France,		Aug., 1885,	1	166
SCALABRE-DELCOURS FILS, Tourcoing, France,		Oct., 1885,	1	76
ALBERT POLLET, Tourcoing, France,		Aug., 1885,	1	104
TIBERGHIEN FRERES, Carders, Tourcoing, France,	1st do	Oct., 1885,	5	1200
do do do do do	3d do	Aug, 1887,		
MARTIAL DASSOUVILLE, do do		April, 1886,	1	61
ED. CALAME, Spinner, Epinal, France,		Dec., 1884,	2	150
SOCIETE POUYER-QUERTIE, Spinning, Rouen, France,	1st do	Dec., 1885,	4	512
do do do do	2d do	Sept., 1886,		
ARMAND PEYNAUD, Spinner & Weaver, Charleval, Fr.,	1st do	May, 1886,	4	480
do do do do	2d do	Sept., 1886,		
HELZINGER ET FILS, Weavers, Charleval, France,		May, 1886,	1	61
C. ZENTZ & CO., Beauvais, France,		May, 1886,	1	104

			Boilers.	H. P.
BAUDOIN, RISLER ET CIE., Spinners, Luxeuel, France,		Aug., 1886,	1	136
IRÉNÉ BRUN & CO., Lace, St. Chamond, France,		May, 1888,	1	92
J. PONGS, Jr., Neuwerk, Germany,		May, 1885,	1	120
JULIUS RIPPERT, Forst, Germany,		Dec., 1886,	1	136
TORRABADILLA HERMANOS, Spinners, Barcelona, Spain,		Feb., 1886,	2	90
JOSÉ SALGOT, Weaver, Barcelona, Spain,		May, 1885,	1	15
PABLO SAN SALVADOR, Weaver, Barcelona, Spain,		May, 1886,	2	40
P. MALJUTIN, Rimenskoje, Russia,		July, 1885,	1	92
G. CORNET, Pondicherry, India,	1st do	Oct., 1884,	8	820
do do do	6th do	June, 1887,		

WOOL, WORSTED, &c.

WORUMBO MFG. CO., Lisbon Falls, Me.,		May, 1885,	2	272
D. R. CAMPBELL, Sangerville, Me.,		Aug., 1887,	2	122
J. W. BUSIEL & CO., Granite Hosiery Mills, Laconia, N. H.,		Aug., 1882,	1	82
FRANK P. HOLT, Hosiery, Laconia, N. H.,		Aug., 1886,	1	73
UNION MANUFACTURING CO., Wolcottsville, Conn.,		Dec., 1881,	2	200
WARREN WOOLEN CO., Stafford Springs, Conn.,	1st do	Jan., 1883,	2	228
do do do	2d do	Sept., 1883,		
HALL BROS., Norwich, Conn.,		Jan., 1884,	2	208
SPRINGVILLE CO., Rockville, Conn.,		June, 1887,	2	244
ROOT MFG. CO., Hosiery, Cohoes, N. Y.,		Oct., 1886,	1	51
RARITAN WOOLEN MILL, Raritan, N. J ,	1st order,	Sept., 1878,	6	1060
do do do	3d do	April, 1886,		
SOMERSET MFG. CO., Raritan, N. J.,	1st do	Dec., 1879,	4	720
do do	2d do	Mar., 1881,		
BOUND BROOK WOOLEN MILLS, Bound Brook, N. J.,	1st do	Oct., 1878,	5	695
do do do	4th do	Jan., 1881,		
FAIRMOUNT WORSTED MILLS, Philadelphia, Pa.,	1st do	Aug., 1879,	3	416
do do do	2d do	Aug., 1882,		
KEYSTONE MILLS, Philadelphia, Pa.,		Dec., 1879,	2	150
M. A. FURBISH & SON, Philadelphia, Pa.,		Sept., 1880,	4	500
PENN WORSTED MILLS, Philadelphia, Pa.,	1st do	Oct., 1883,	2	212
do do do	2d do	Sept., 1886,		
LEWIS S. COX & CO., Philadelphia, Pa.,		Oct., 1883,	2	150
THOMAS JAGGERS, Yarns, Philadelphia, Pa.,		April, 1883,	1	104
J. C. GRAHAM, Dress Trimmings, Philadelphia, Pa.,		Nov., 1885,	1	73
CONSHOHOCKEN Worsted Mills, Conshohocken, Pa.,	1st do	June, 1881,	5	824
do do do	3d do	Mar., 1883,		
THE F. GRAY CO., Piqua, Ohio,		Mar., 1885,	1	104
EAGLE KNITTING CO., Elkhart, Ind.,	1st do	May, 1882,	2	100
do do	2d do	July, 1887,		
OLD KENTUCKY WOOLEN MILLS, Louisville, Ky.,	1st do	Nov., 1883,	3	312
do do	2d do	July, 1887,		
COOPER, WELLS & CO., St. Joseph, Mich.,		Jan., 1883,	1	83
THE BUELL MFG. CO., St. Joseph, Mo.,		Mar., 1883,	1	150
ROSAMOND WOOLEN MILLS, Almont, Ont., Canada,	1st do	April, 1878,	5	362
do do do do	2d do	April, 1883,		
MONTREAL WOOLEN MILLS, Montreal, Canada,		Mar., 1888,	1	108
CHARTERIES, SPENCE & CO., Tweeds, Dumfries, Scotland,		Aug., 1886,	1	120
CAULLIEZ PERE, FILS & DELAOUTRE, Tourcoing, France,		June, 1887,	2	488

		Boilers.	H. P.
JOHN BOUTIKOFF, Weaver & Spinner, Moscow, Russia,	July, 1885,	2	164
ALBERT HUBNER, Weaver, Moscow, Russia,	Feb., 1885.	1	45
EGERTON WOOLEN MILLS, Dharival, Punjab, India,	Oct., 1886,	1	120

SILKS.

CHENEY BROS., South Manchester, Conn.,	Oct., 1880,	2	300
LOUIS FRANKE & CO., Paterson, N. J.,	April, 1880,	2	150
S. MEYENBERG, Hoboken, N. J.,	Nov., 1880,	1	75
ONEIDA COMMUNITY, Limited, Community, N. Y.,	Mar., 1888,	1	61
CORRIVEAU & CO., Montreal, Canada,	Jan., 1882,	1	100
JAMES MELVILLE & SONS, Hazelden, Mearns, Scotland,	May, 1883,	1	104
LISTER & CO., MANNINGHAM MILLS, Bradford, England,	Feb., 1885,	1	136
MOTTE BOSSUT FILS, Velvets, Leers, France,	Aug., 1885,	1	136
CHRISTOPH ANDREAL, Mülheim-on-Rhine, Germany,	Aug., 1884,	1	120

CARPETS.

ALEX. SMITH & SONS CARPET CO., Yonkers, N. Y.,	1st order, July, 1883,	7	1324
do do do do	5th do Dec., 1887,		
JONATHAN RING & SON, Philadelphia, Pa.,	Sept., 1883,	1	104
CALEDONIA MILLS, Philadelphia, Pa.,	Oct., 1883,	4	416
WM. WHITAKER & SONS, Philadelphia, Pa.,	1st order, Aug., 1879,	4	500
do do do	2d do May, 1883,		
MITCHELL BROS., Waterfoot, England,	Oct., 1885,	2	248
A. SAMPSON & SONS, Oil-cloths, Newtown, L. I., N. Y.,	Aug., 1882,	2	108
JOHN BARRY, OSTLERE & CO., Linoleum, Kirckaldy, Scotland,	Aug., 1884,	5	1040
do do do	4th order, Jan., 1888,		
THOS. BRIGGS, Oil-cloth, Salford, England,	Nov., 1885,	1	124

DYE WORKS AND BLEACHERIES.

JAMES MARTIN & CO., Philadelphia, Pa.,	1st do Dec., 1880,	2	208
do do do	2d do April, 1881,		
QUAKER CITY DYE WORKS CO., Philadelphia, Pa.,	Sept., 1881.	2	272
JAS. McLARDIE & SONS, Paisley, Scotland,	1st do Dec., 1883,	2	187
do do	2d do Oct., 1886,		
HEPBURN & CO., Ramsbottom, Scotland,	Jan., 1884,	1	136
P. &. P. CAMPBELL, Perth, Scotland,	April, 1886,	1	146
JAS. SMITH & SONS, Yarn Dyers, Heywood, Eng.,	Oct., 1884,	1	120
J. & J. M. WORRALL, Manchester, Eng.,	1st order, Sept., 1884,	5	636
do do	3d do —— 1887.		
S. SCHWABE & CO., Bleachers, Manchester, England,	Dec., 1886,	2	186
HANNART FRERES, Roubaix & Wasquehal, France,	4 orders, 1885-6,	5	826
BROWAEYS-DEGEYTER FRERES, Roubaix, France,	1st order, Sept., 1885,	2	346
do do do	2d do Feb., 1887,		
ERNOULT BAYART, Dyer, Roubaix, France,	Nov., 1885.	1	186
E. ROUSSEL, Dyer, Roubaix, France,	1st order, Feb., 1887,	3	558
do do do	2d do Dec., 1887,		

		Boilers.	H. P.
COCHETEUX & CO., Dyers, Roubaix, France,	April, 1887,	1	193
DUBOIS & CHARVET, Columbier, Armentieres, France,	1st order, Feb., 1885,	4	476
do do do	2d do Aug., 1885,		
J. LAUREAU, Dyer, Paris, France,	Aug., 1885,	1	25
ELMER FRERES, Lyons, France,	1st do Jan., 1886,	2	208
do do	2d do June, 1886,		
WALLERAUD, WIART, WATRAMEZ, JACQZ ET CIE., Cambrai, France,	June, 1886,	2	416
SUCCESORES DE FRANCISCO ROURA, Farrasa, Spain,	Jan., 1886,	1	30
PIETRO ANGELO BOGGIO, Dyer, Strona, Biella, Italy,	Feb., 1887,	1	45

OILS, GLUE, AND CHEMICAL WORKS.

STANDARD OIL CO., Bayonne, N. J., and elsewhere,	1st order, Dec., 1880,	45	6634
do do do do	36th do Dec., 1886,		
BROOKLYN OIL REFINERY, Brooklyn, N. Y.,	1st do May, 1879,	6	728
do do do	3d do Feb., 1882,		
PRATT MFG. CO., Brooklyn, N. Y.,	1st do July, 1881,	9	1482
do do	6th do April, 1886,		
SONE & FLEMING MFG. CO., Brooklyn, N. Y.,	1st do May, 1882,	4	416
do do	2d do Dec., 1887,		
CHESEBROUGH MFG. CO., Brooklyn, N. Y.,	1st order, Sept., 1881,	2	245
do do	2d do Sept., 1883,		
HOWE LARD OIL CO., Long Island City, N. Y.,	May, 1882,	2	120
LOMBARD, AYRES & CO., Refinery, Bayonne, N. J.,	1st do April, 1879,	15	2246
do do do	15th do Jan., 1888,		
NATIONAL TRANSIT CO., Rutherford Park, N. J.,	1st do Feb., 1881,	5	520
do do	2d do Dec., 1881,		
ATLANTIC REFINING CO., Philadelphia, Pa.,	1st do Aug., 1881,	7	1111
do do	5th do Jan., 1886,		
BELMONT OIL WORKS, Philadelphia, Pa.,	1st do Sept., 1881,	2	333
do do do	2d do Dec., 1885,		
ORR, LEONARD & CUMMINGS, Oil, Philadelphia, Pa.,	Mar. 1884,	1	104
BALTIMORE UNITED OIL CO., Baltimore, Md.,	Dec., 1886,	1	120
MAGINNIS OIL MILL, New Orleans, La.,	July, 1882,	2	360
GEO. UPTON, Glue, Peabody, Mass.,	1st do Jan., 1882,	2	280
do do	2d do Mar., 1884,		
PETER COOPER'S Glue Factory, Brooklyn, N. Y.	1st do Sept., 1880,	4	500
do do	2d do Aug., 1881,		
BAEDER, ADAMSON & CO., Philadelphia, Pa.,	1st do Oct., 1879,	7	979
do do	5th do July, 1883,		
do Newark, N. J..	May, 1884,	1	136
OLIVER JOHNSON & CO., Paints, Drugs, &c., Providence, R. I.,	July, 1884,	1	51
RUMFORD CHEMICAL WORKS, Providence, R. I.,	1st order, May, 1880,	4	283
do do	2d do Nov., 1885,		
CHURCH & CO., Chemicals, Brooklyn, N. Y.	1st do Feb., 1880,	4	592
do do	4th do Oct., 1887,		
CHAS. LENNIG, Chemicals, Philadelphia, Pa.,	1st do Dec., 1880,	2	166
do do	2d do Jan., 1881,		
KEASBEY & MATTISON, Chemicals, Ambler, Pa.,	Sept., 1883,	1	75
STAUFFER & CO., Chemicals, San Francisco, Cal.,	Jan., 1886,	1	73
GLEN COVE MFG. CO., Starch, Glen Cove, L. I., N.Y.,	June, 1882,	2	300

			Boilers.	H. P.
C. GILBERT, Starch, Des Moines, Iowa,	1st order,	Nov., 1882,	4	488
do do	2d do	Mar., 1884,		
ORIENT GUANO MFG. CO., Orient, N. Y.,		June, 1881,	1	104
C. MEYER, Bone-black, Maspeth, N. Y.,		Oct., 1884,	1	73
WALTON & WHANN CO., Phosphates, Wilmington, Del.,	1st order,	May, 1873,	6	587
do do do	4th do	Nov., 1881,		
PENDLETON GUANO CO., Atlanta, Ga.,		Sept., 1881,	1	104
CORNWALL & BRO., Soaps and Candles, Louisville, Ky.,	1st do	Oct., 1874,	4	225
do do do	4th do	Oct., 1883,		
MICHIGAN CARBON WORKS, Detroit, Mich.,	1st do	April, 1881,	4	500
do do	3d do	July, 1885,		
PRUSSING VINEGAR CO., Chicago, Ill.,		Nov., 1881,	1	104
THE SOLVAY PROCESS CO., Syracuse, N. Y.	1st do	June, 1882,	19	4452
do do	6th do	June, 1886,		
SOLVAY & CIE., Whylen, Grand Duche de Baden,	1st order,	Dec., 1881,		
do do	2d do	Feb., 1882,		
do Dombasle sur Murthe, France,	1st do	Dec., 1881,	10	1220
do do	2d do	Aug., 1882,		
do Coaillet. Belgium,		Aug., 1883,		
YOUNG'S PARAFFINE LIGHT & MINERAL OIL CO., Addiewell, Scotland,		Sept., 1883,	1	120
J. & G. COX, Glue and Gelatine, Edinburgh, Scotland,	1st do	Aug., 1882,	2	146
do do do do	2d do	June, 1886,		
JAMES ROSS & CO., Falkirk, Scotland,		Sept., 1883,	1	82
BROXBURN OIL CO., Broxburn, Scotland,		May, 1883,	1	140
FARQUHAR & GILL, Aberdeen, Scotland,		Mar., 1887,	1	40
M. DUBOIS, Chemicals, St. Denis, France,		June, 1885,	1	61
PH. LEYSEN FILS, Starch, Vesuiet, France,		Mar., 1886,	2	240
DAIRE, E. ANSELIN & CO., Soap, Arras, France,		Oct., 1886,	1	35
GILLIARD, MOUNET ET CARTIER, Chemicals, Lyons, France,		Dec., 1886,	2	240
A. GERMOT, Chemicals, Argenteuil, France,		Mar., 1887,	1	25
MALEZIEUX & CO., Chemicals, Bondy, near Paris, France,		April, 1887,	1	120
MATTEO DUBICH, Oil, Trieste, Austria,		June, 1886,	1	145
THE NEWSKY STEARINE CANDLE FACTORY, Moscow, Russia,		Sept., 1886,	2	70

STEAM HEATING AND POWER.

N. Y. STEAM COMPANY, New York,	1st order,	July, 1880,	56	13482
do do do	14th do	July, 1887,		
"VAN CORLEAR" (Apartment House), New York,	1st do	Dec., 1878,	4	268
do do do	3d do	June, 1885,		
"DAKOTA" (Apartment House), New York,	1st do	Aug., 1882,	6	864
do do do	2d do	May, 1886,		
"THE ALBANY" (Apartment House), New York,		Sept., 1879,	1	90
"MADRID" (Apartment House), New York,		May, 1883,	2	122
"BARCELONA" do do		May, 1883,	2	125
COLUMBIA COLLEGE, School of Mines, New York,	1st do	July, 1879,	5	400
do do do	2d do	June, 1882,		
COLLEGE OF THE CITY OF NEW YORK,		Dec., 1884,	1	35
NEW YORK PRODUCE EXCHANGE, New York,		Feb., 1884,	3	624
CONSOLIDATED STOCK & PETROLEUM EXCHANGE, N. Y.,		Oct., 1887,	2	146

			Boilers.	H. P.
MUTUAL LIFE INSURANCE CO., New York,		Mar., 1884,	4	488
AMERICAN INSTITUTE, New York,		June, 1882,	2	250
NEW YORK HERALD, (Bennett Building), New York,		Oct., 1884,	2	244
F. W. STILLMAN, New York,	1st do	July, 1881,	2	150
do do	2d do	July, 1882,		
CORPORATION OF TRINITY CHURCH, New York,		Sept., 1882,	3	160
NURSERY AND CHILD'S HOSPITAL, New York,		April, 1879,	1	50
DEPT. OF DOCKS, Pier A, N. R., New York,	1st do	Sept., 1885,	2	35
do do do	2d do	Sept., 1886,		
PAREPA HALL, N. Y. City,	1st do	Nov., 1883,	2	50
do	2d do	Oct., 1885,		
ST. PAUL'S SCHOOL OF THE CATHEDRAL, Garden City, N.Y.,		Nov., 1884,	1	104
CORNELL UNIVERSITY, Ithaca, N. Y.,	1st do	Oct., 1885,	2	561
do do	2d do	Mar., 1888,		
CROUSE MEMORIAL BUILDING, Syracuse, N. Y.,		July, 1888,	2	208
C. J. HAMLIN, Buffalo, N. Y.,		June, 1888,	2	208
EDMUND M. WOOD & CO., Nursery, Boston, Mass.,		Aug., 1882,	1	50
MASSACHUSETTS INSTITUTE of TECHNOLOGY, Boston, Mass.,		Apr., 1888,	1	208
U. S. NAVAL TRAINING STATION, Newport, R. I.,		Sept., 1884,	2	122
TAYLOR'S HOTEL, Jersey City, N. J.,		Oct., 1881,	1	50
HAMBURG-AMERICAN PACKET CO., Hoboken, N. J.,		July, 1882,	2	208
COLES BUILDING, Newark, N. J.,		July, 1885,	1	107
COUNTY OF UNION COURT HOUSE, Elizabeth, N. J.,		Oct., 1874,	1	40
COLLEGE OF NEW JERSEY, Princeton, N. J.,		April, 1879,	1	30
PUBLIC SCHOOL, Plainfield, N. J.,		May, 1883,	1	35
G. W. CHILDS (Public Ledger Building), Philadelphia, Pa.,	1st order,	Aug., 1873,	3	150
do do do	2d do	Sept., 1882,		
HOTEL LAFAYETTE, Philadelphia, Pa.,	1st do	April, 1872,	3	230
do do	2d do	Sept., 1881,		
GIRARD ESTATE, People's Bank, Philadelphia, Pa,,		Sept. 1876,	1	50
do do Stores do	2d order,	April, 1886,	6	716
do do do do	4th do	Dec., 1887,		
BINGHAM HOUSE, Philadelphia, Pa.,		May, 1885,	2	80
FIDELITY INS., TRUST & SAFE DEPOSIT CO., Philadelphia, Pa.,		May, 1886,	1	92
SHARPLESS BROS., Dry Goods, Philadelphia, Pa.,		May, 1881,	1	100
WILLIAM WEIGHTMAN, Stores, Philadelphia, Pa.,	1st order,	Nov., 1872,	6	410
do do do	2d do	Dec., 1887,		
R. D. WOOD & SONS, Philadelphia, Pa.,		Aug., 1881,	2	100
PENNSYLVANIA R. R. CO., General Offices, Phil'a, Pa.,	1st order,	Sept., 1883,	3	312
do do do do	2d do	Apr., 1887,		
GEO. S. HARRIS, Philadelphia, Pa.,	1st do	Apr., 1886,	2	120
do do	2d do	Apr., 1887,		
GLEN SUMMIT HOTEL & LAND CO., Glen Summit, Pa.,	1st do	July, 1883,	2	60
do do	2d do	Nov., 1884,		
GEO. WESTINGHOUSE, Jr., Pittsburgh, Pa.,		June, 1887,	2	170
WESTINGHOUSE BUILDING, Pittsburgh, Pa.,		Mar., 1888,	3	152
U. S. CAPITOL, SENATE WING, Washington, D. C.,		Mar., 1887,	2	312
DEPT. OF THE INTERIOR, do		June, 1888,	2	122
WESTERN LUNATIC ASYLUM, Staunton, Va.,		Sept., 1883,	2	122
LURAY CAVE & HOTEL CO., Luray, Va.,		May, 1887,	1	45
HAMPTON NORMAL & AGR'L INSTITUTE, Hampton, Va.,		July, 1888,	1	120
H. I. KIMBALL HOUSE, Atlanta, Ga.,		Oct., 1884,	2	120
STATE LUNATIC ASYLUM, near Milledgville, Ga.,		Nov., 1887,	1	136

		Boilers.	H. P.
HOTEL PONCE DE LEON, St. Augustine, Fla.,	Apr., 1887,	4	416
CENTRAL KENTUCKY LUNATIC ASYLUM, Anchorage, Ky.,	Aug., 1883,	6	450
THE VANDERBILT UNIVERSITY, Nashville, Tenn.,	1st order, June, 1880,	3	202
do do	2d do Dec., 1885,		
UNIVERSITY OF NOTRE DAME, South Bend. Ind.,	Sept., 1885,	1	40
IND. SOLDIERS' & SAILORS' ORPHANS' HOME, Knightstown, I.,	Sept., 1887,	2	240
NORTHERN HOSPITAL FOR INSANE, Logansport, Ind.,	July, 1885,	4	400
EASTERN do Richmond, Ind.,	July. 1885,	4	400
SOUTHERN do Evansville, Ind.,	July, 1885,	4	400
NORTHERN do Elgin, Ill.,	Sept, 1885,	1	75
GAFF BUILDING, Chicago, Ill.,	Aug., 1881,	1	104
CHICAGO, BURLINGTON & QUINCY R. R., Chicago. Ill.,	Aug., 1887	1	136
UNIVERSITY OF CALIFORNIA, Berkeley, Cal.,	April, 1885,	1	15
PACIFIC POWER CO., San Francisco, Cal.,	May, 1885,	2	208
PUBLIC BATHS, Mexico, Mex.,	Feb., 1884,	1	15
COMPANIA DE ALMACENES de Deposito de la Habana, Cuba,	Sept., 1884,	1	104
GREENOCK PRISON, Scotland,	Sept., 1885,	2	20
CALTON PRISON, Edinburgh, Scotland,	1st order, Oct., 1885,	3	124
do do	2d do July, 1886,		
DRUMSHENGH BATHS, do	1st order, June, 1884,	2	28
do do	2d do Aug., 1885,		
ALEXANDER SMITH, Town House, Aberdeen, Scotland,	Feb., 1888,	1	20
PUTNEY SWIMMING BATHS, London, England,	Oct., 1885,	1	20
A. D. DUNN, Laundry, London, England,	May, 1885,	1	34
LONDON & TILBURY LAUNDRY CO., Tilbury, England,	Mar., 1886,	2	216
COLLEGE OF GRENOBLE, France,	May, 1886,	3	120
NATIONAL LIBERAL CLUB, London, England,	Aug., 1886,	2	194
JAS. LESLIE WONKLYN, Mont Dore Hotel, Bournemouth, Eng.,	May, 1888,	1	65

GRAIN AND FLOUR.

PIONEER MILLS, Cooperstown, N. Y.,	Aug., 1878,	2	150
THORNTON & CHESTER, Buffalo, New York,	Nov., 1881,	1	108
ERIE ELEVATOR, Jersey City, N. J.,	Aug., 1879,	4	500
H. K. CUMMINGS & CO., Philadelphia, Pa.,	July, 1880,	1	104
J. C. KLAUDER. Philadelphia, Pa.,	April, 1882,	1	50
McGREW, PARKISON & CO., Monangahela City, Pa.,	Jan., 1883,	1	61
H. JULIUS KLINGLER & Co., Butler, Pa.,	Aug., 1883,	1	92
WM. LEE & SONS Co., Wilmington, Del.,	1st order, April, 1881,	3	275
do do	2d do Oct., 1883,		
A. H. SIBLEY, Baltimore, Md.,	1st do May, 1882,	2	250
do do	2d do July, 1887,		
KENNESAW MILLS, Marietta, Ga.,	May, 1881,	2	200
LANIER MILL CO., Nashville, Tenn.,	July, 1881,	2	120
MEMPHIS MILL CO., Memphis, Tenn.,	Feb., 1886,	2	164
VALLEY CITY MILLING CO., Grand Rapids, Mich.,	Jan., 1885,	1	122
VOIGT MILLING CO., Grand Rapids, Mich.,	1st order. Oct., 1886,	2	280
do do	2d do Sept., 1887,		
GEO. P. PLANT MILLING CO., St. Louis, Mo.,	1st order, Aug., 1883,	4	708
do do do	2d do Oct., 1887,		
GENESEE MILL CO., San Francisco, Cal.,	April, 1882,	1	136
DEMING-PALMER MILLING CO., San Francisco, Cal.,	Dec., 1883,	1	208

		Boilers.	H. P.
ALBAITERO & ARRACHE, Mexico, Mex.,	Aug., 1886,	2	184
BONIFACIO LEYCEGUI, Silao, Mexico,	Oct., 1880,	1	60
MANSON & CO., Aberdeen, Scotland,	Jan., 1887,	1	104
W. & P. R. ODLUM, Corn Millers, Port Arlington, Ireland,	June, 1884,	1	104
WM. HUGHES, Shrewsbury, England,	Jan., 1885,	1	61
MITCHELL BROS., Whitefoot, England,	Oct., 1885,	2	248
BANQUE DE PARIS ET DES PAYS-BAS, Paris, France,	Mar., 1886,	1	240
M. FENET, Goussainville, France,	July, 1886,	1	61
A. REYNAUD, Marseilles, France,	July, 1887,	1	35
LOUIS CARRIE, do do	Oct., 1887,	1	51
JOSÉ SORT, Lerida, Spain,	May, 1885,	1	25
MICH'L VERDERAME, Paste for Macaroni, Licata, Sicily, 1st do	Jan., 1886,	2	208
do do do 2d do	July, 1887,		
AKMET HUSIANOFF, Orenburg, Russia,	April, 1886,	1	73

COFFEE, SPICES, &c.

ARBUCKLE BROS. COFFEE CO., Brooklyn, N. Y.,	1st order, Nov., 1883,	4	416
do do do	2d do Feb., 1886,		
ARBUCKLES & CO., Spices, Pittsburgh, Pa.,	Mar., 1883,	2	102
TWITCHELL, CHAMPLIN & CO., Grocers, Portland, Me.,	May, 1883,	2	102

ELECTRIC LIGHTING, &c.

EDISON ELECTRIC LIGHT CO., Paris, France,	June, 1881,	1	150
do do London, Eng.,	1st order, June, 1881,	2	300
do do do	2d do June, 1882,		
do do Milan, Italy,	1st do Aug., 1882,	15	1977
do do do	8th do May, 1888,		
do do Livorno, Italy,	Sept., 1887,	3	438
EDISON LAMP CO., Newark, N. J.,	1st do June, 1886,	3	281
do do	2d do July, 1886,		
THOS. A. EDISON, Fort Myer, Fla.,	Nov., 1885,	1	45
do Orange, N. J.,	Aug., 1887,	3	219
EDISON PHONOGRAPH WORKS, Orange, N. J.,	May, 1888,	2	146
EDISON MACHINE WORKS, Schenectady, N. Y.,	1st do Jan., 1881,	5	448
do do do	3d do Sep., 1887,		
EDISON ELECTRIC ILLUMINATING CO., New York,	1st order, Sept., 1881,	14	2620
do do	do 3d do Dec., 1887,		
do do Lawrence, Mass.,	Sept., 1882,	3	286
do do	do 3d order, April, 1884,		
do do Brockton, Mass.,	June, 1883,	2	146
do do Fall River, Mass.,	Oct., 1883,	2	146
do do Newburgh, N. Y..	Nov., 1883,	2	146
do do Paterson, N. J.,	May, 1888,	1	240
do do Sunbury, Pa.,	May, 1883,	1	51
do do Shamokin, Pa.,	June, 1883.	2	146
do do Hazleton, Pa.,	Nov., 1883,	1	92
do do Bellefonte, Pa.,	1st order, Nov., 1883,	2	184
do do	do 2d do May, 1885.		
do do Mt. Carmel, Pa.,	Nov., 1883,	1	51

		Boilers.	H. P.
EDISON ELECTRIC ILLUMINATING CO., Tiffin, Ohio,	Nov., 1883,	1	92
do do Middletown, Ohio,	1st order, Dec., 1883,		
do do do 2d do	Aug., 1884,	2	143
do do Piqua, Ohio,	Mar., 1884,	1	92
do do Circleville, Ohio,	April, 1884,	1	92
do do New Orleans, La.,	June, 1888,	2	312
EDISON CO. FOR ISOLATED LIGHTING, Washington, D. C.,	April, 1884,	2	164
do do *N. Y. Herald*, N. Y. City,	Nov., 1881,	1	150
WESTERN EDISON ELECTRIC LIGHT CO., Chicago, Ill.,	July, 1882,	1	40
U. S. ELECTRIC LIGHT CO., New York,	1st order, Feb., 1880,		
do do	2d do Dec., 1880,	3	233
do Philadelphia, Pa.,	Mar., 1885,	1	208
do Weston Factory, Newark, N. J.,	1st do Oct., 1880,		
do do do	4th do Sept., 1887,	5	389
BRUSH ELECTRIC LIGHT CO., Philadelphia, Pa.,	July, 1881,	4	300
BRUSH-SWAN ELECTRIC LIGHT CO., Auburn, N. Y.,	Sept., 1885,	1	60
ELECTRIC CLUB, New York, N. Y.,	June, 1887,	1	74
HARLEM LIGHTING CO., New York, N. Y.,	Sept., 1887,	1	300
WESTINGHOUSE ILLUMINATING CO., Schenectady, N. Y.,	Oct., 1887,	2	292
ALLEGHENY COUNTY ELECTRIC LIGHT CO., Pittsburg, Pa.,	Jan., 1888,	2	365
HOUSE OF REPRESENTATIVES, Washington, D. C.,	1887,	1	82
BUCYRUS ELECTRIC LIGHT CO., Bucyrus, Ohio,	June, 1887,	1	85
ST. JOSEPH ELECTRIC LIGHT CO., St. Joseph, Mo.,	1st order, July, 1883,		
do do do	2d do Aug., 1884,	2	102
KANSAS CITY ELECTRIC LIGHT CO., Kansas City, Mo.,	Sept., 1886,	1	127
A. HAYWARD, San Mateo, Cal.,	July, 1887,	1	51
ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CO., Edinburgh, Scotland,	Jan., 1887,	1	25
ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CO., for Royalty Theatre, Edinburgh, Scotland,	Dec., 1887,	1	25
ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CO., L'T'D, Bosworth, Scotland,	Aug., 1887,	1	20
McWHIRTER, FERGUSON & CO, Edinburgh, Scotland,	Aug., 1887,		
do do do do	Apr., 1888,	2	91
SIR COUTTS, LINDSAY & CO., Grosvenor Gallery, London, Eng.,	Oct., 1886,	4	956
CARDOGAN ELECTRIC LIGHT CO., London, England,	Oct., 1887,	2	208
EDISON-SWAN ELECTRIC LIGHT CO., London, Eng.,	Jan., 1888,	3	468
LONDON ELECTRIC SUPPLY CORP'N, L't'd, London, Eng.,	Feb., 1888,		
do do do 2d order,	Mar., 1888,	13	3093
S. Z. FERRANTI, Electrician, London, England,	Feb., 1888,	1	85
THE HOUSE-TO-HOUSE ELECTRIC LIGHT SUPPLY CO., Kensington, London, England,	May, 1888,	3	468
THE SCHMIDT-DOUGLASS ELECTRIC LIGHT CO. Lmt'd, Huskegate, Bradford, England,	2 orders, 1887,	2	235
RESIDENCE OF MR. BRYANT, Dorking, England,	Sept., 1885,	2	25
RESIDENCE OF LORD ROTHSCHILD, Tring Park, Herts, Eng.,	June, 1887,	1	60
THE CHATHAM, ROCHESTER & DISTRICT ELECTRIC LIGHTING CO., Rochester, England,	Jan., 1888,	1	124
ELECTRICITEITS MATTSCHAPPY, SYSTEM DE KHOTINSKY, Rotterdam, Holland,	Oct., 1884,	2	164
ELECTRICITEITS MATTSCHAPPY, SYSTEM DE KHOTINSKY, Berlin, Germany,	1st order, June, 1887,		
do do do	2d order, Aug., 1887,	3	135
CAPT. DE KHOTINSKY, Rotterdam, Holland, for Berlin,	June, 1887,	2	80
HOTEL DE LILLE ET ALBION, Paris, France,	May, 1886,	1	20
COMPAGNIE FRANCAISE L'ECLAIRAGE ELECTRIQUE, Paris, France,	1st order, Sept., 1887,		
COMPAGNIE FRANCAISE L'ECLAIRAGE ELECTRIQUE, Paris, France,	2d order, Feb., 1888,	3	518
ROYAL ITALIAN NAVY ARSENAL, Spezia, Italy,	May, 1888,	3	186
E. LAMY, P. RIEU & CO, Mende, France,	June, 1887,	2	122
A GILLIBERT & CO, Marseilles, France,	Oct., 1887,	2	220
SOCIETA PER L'ILLUMINAZIONE ELETTRICA, Palermo, Italy,	Sept., 1887,	2	164
VIENNA OPERA HOUSE, VIENNA, Austria,	1st order, Nov., 1887,		
do do	2d do Apr., 1888,	8	992
FRANCISCO DE LA VIESCA, Cadiz, Spain,	1st order, Sept., 1886,		
do do do	2d order, April, 1887,	2	102
CAMELA G. LAGANA, Palermo, Sicily,	1st order, Sept., 1886,		
do do	2d order, Aug., 1887,	2	122

GAS LIGHTING.

WALTHAM GAS LIGHT CO., Waltham, Mass.,	Dec., 1886,	1	156
STANDARD GAS LIGHT CO., New York, N. Y.,	Aug., 1887,	2	500
WILLIAMSBURGH GAS LIGHT CO., Brooklyn, N. Y.,	Aug., 1884,	1	164
EAST RIVER GAS LIGHT CO. L. I. City, N. Y.,	1st order, Sept., 1886,		
do do	2d do July, 1888,	2	102
CINCINNATI GAS LIGHT AND COKE CO., Cincinnati, Ohio,	Mar., 1883,	2	184
CITIZENS' GAS LIGHT AND HEATING CO., Bloomington, Ill.,	April, 1884,	1	51
ABERDEEN CORPORATION, Aberdeen, Scotland,	Jan., 1886,	1	93
SOCIETA ANGLO-ROMANA per L'ILLUMINAZIONE, Rome, Italy,	Dec., 1885,		
do do do do	Sept., 1887,	9	1362
EDINBURGH & LEITH GAS WORKS, Leith, Scotland,	July, 1887,	2	186

PAPER AND PRINTING.

AMERICAN BANK NOTE CO., New York,	Sept., 1884,	2	240
CUMBERLAND & PRESUMPSCOT MILLS, Cumberland Mills, Me.,	1st order, July, 1883,		
do do	3d do Jan., 1888,	9	952
S. D. WARREN & CO., Copsecook Mills, Gardner, Me.,	July, 1884,	2	184
FOREST PAPER CO., Yarmouthville, Me.,	May, 1883,	1	164
MONADNOCK MILLS, Bennington, N. H.,	Dec., 1883,	1	61
C. B. COTTRELL & SONS, Printing Presses, Westerly, R. I.,	Sept., 1882,	1	73
S. Y. BEACH PAPER CO., Seymour, Conn.,	April, 1872,	1	60
WAIT & RICHARDS, Sandy Hill, N. Y.,	Aug., 1883,	2	164
CHAS. VAN BENTHUYSEN & SONS, Printers, Albany, N. Y.,	Aug., 1883,	1	73
D. A. BULLARD & SONS, Schuylerville, N. Y.,	April, 1884,	1	122
WM. C. HAMILTON & SONS, Lafayette, Pa.,	Oct., 1881,	8	1000
MARTIN & W. H. NIXON, Manayunk, Philadelphia, Pa.,	1st order, April, 1881,		
do do do	6th do Oct., 1884,	13	1749

			Boilers.	H. P.
J. K. WRIGHT & CO., Printers' Inks, Philadelphia, Pa.,		Sept., 1882,	1	50
GEO. S. HARRIS & SONS, Printers, Philadelphia, Pa.,		May, 1881,	1	75
DAGER & COX, Paper, Bridgeport, Pa.,	1st order,	Nov., 1883,	2	196
do do	2d do	June, 1884,		
PENNSYLVANIA PULP & PAPER CO., Lock Haven, Pa.,		Dec., 1883.	2	164
WESTMORELAND PAPER CO., West Newton, Pa.,		—— 1884,	4	752
do do do	2d order,	June, 1888,		
PHILADELPHIA LEDGER PAPER MILLS, Elkton, Md.,		Oct., 1872,	2	100
CECIL PAPER CO, (Lim,), Elkton, Md.,		Aug., 1883,	1	60
SUSQUEHANNA WATER POWER & PAPER CO., Conowingo, Md.,		2 orders, 1883-4,	4	328
FARM & FIRESIDE, Springfield, O.,		July, 1881,	1	50
WARDLOW THOMAS PAPER CO., Middletown, O.,	1st order,	June, 1881,	4	490
do do	3d do	April, 1883,		
TYTUS PAPER CO., Middletown, O.,	1st do	Feb., 1882,	3	625
do do	2d do	Dec., 1883,		
GARDNER PAPER CO., do		Oct., 1886,	2	250
EAGLE PAPER CO., Franklin, O.,	1st do	Jan., 1883,	3	375
do do	2d do	June, 1888,		
PORTAGE STRAW BOARD CO., Circleville, O.,		Sept., 1883,	16	1472
GLASS EDSELL PAPER CO., Delaware, Ohio	1st order,	April, 1883,	3	258
do do do	2d order,	Dec., 1887,		
VAN NORTWICK PAPER CO., Batavia, Ill.,		July, 1888,	1	125
KAUKAUNA PAPER CO., Kaukauna, Wis.,		July, 1888,	2	250
CEDAR FALLS PAPER CO., Cedar Falls, Ia.,	1st order,	Feb., 1882,	2	197
do do	2d do	Feb., 1883,		
KANSAS CITY JOURNAL, Kansas City, Mo.,		Mar., 1887,	2	200
LICK PAPER CO., Agnews, Cal.,	1st order,	Dec., 1883,	3	256
do do	2d do	Oct., 1884,		
JUAN M. BENFIELD, Paper, Mexico, Mex.,		June, 1887,	1	122
JOHN COLLINS, Denny, Scotland,	1st do	Aug., 1885,	3	321
do do	3d do	Aug., 1886,		
do Milton Paper W'ks, Dowling, Scotland,	1st do	Nov., 1885,	1	104
MARTIN & CO. (Lim.), Millboard Mfrs., Craiginarlock, Scotland,		Oct., 1883,	1	82
BROWN, STEWART & CO., Greenock, Scotland,		Mar., 1886,	1	156
ALEXANDER MARR, Newspaper, Aberdeen, Scotland,		Feb., 1888,	2	50
S. H. COWELL, Printer, Ipswich, England,		Mar., 1883,	1	35
J. WESTCOTT & SONS, Paper, Workingham, England,		Oct., 1884,	1	54
GRANT & CO., Printers, London, England,		Nov., 1884,	1	81
SPICER BROS., Paper, London, England,		Oct., 1885,	1	20
W. & A. TREMLET, Paper, Exeter, England,	1st order,	Oct., 1885,	2	291
do do	2d do	Sept., 1887,		
JOHN DICKINSON & CO. (Lim.), Hemel Hempstead, England,		Jan., 1887,	4	720
do do do		Sept., 1887,		
TAKATA & CO., London, for Paper Mill, Japan,		Dec., 1887,	3	349
EVANS & McEWEN, Cardiff, Wales,		Dec., 1887,	1	140
CHAS. UNSINGER, Printer, Paris, France,		Nov., 1886,	1	50
IMPRIMERIE FRANCAISE, Paris, France,		Jan., 1888,	2	126
PAUL VARIN, Jean d'Heurs, France,		July, 1887,	2	222
ARRA Y CIA, Paper, Tolosa, Spain,		Feb., 1886,	1	51
RICART Y CIA, Paper, Villanueva, Spain,		Jan., 1886,	1	61
LA VIUDA BORE, Castelfullit, Spain,		Oct., 1886,	1	30
NEUSSER PAPER WORKS, Neuss, Germany,		April, 1886,	2	208

LEATHER.

			Boilers.	H. P.
JEWELL BELTING CO., Hartford, Conn.,		July, 1883,	2	164
HOWELL, HINCHMAN & CO., Middletown, N. Y.,		Aug., 1883,	2	164
T. P. HOWELL & CO., Newark, N. J.,	1st order,	Mar., 1883,	3	244
do do	2d do	April, 1886,		
J. MUNDELL & CO., Shoes, Philadelphia, Pa.,		Dec., 1877,	1	40
WM. FOREPAUGH & BRO., Tannery, Philadelphia, Pa.,		Jan., 1881,	2	120
PUSEY & SCOTT CO., Morocco Mfrs., Wilmington, Del.,		Aug., 1872,	1	75
H. S. ROBINSON & BURTENSHAW, Boots and Shoes, Detroit, Mich.,		Mar., 1884,	2	120
PINGREE & SMITH, Boots and Shoes, Detroit, Mich.,		July, 1884,	1	120
WM. WHITMORE, Tanner, Bermondsey, London, England,		Dec., 1884,	2	120
W. R. BRAY, Currier, Bermondsey, London, England,		Oct., 1886,	1	82
WHITMORE & SONS, Tanners, Edenbridge, Kent, England,		Nov., 1885,	1	100
RYMER & SHEPARD, Tanners, Northampton, Eng.,		Feb., 1886,	1	84
A. M. DORMAN, Tanner, Maidstone, Kent, England,		Dec., 1887,	1	86
BEARE & SONS, Tanners, Norwich, England,		Dec., 1887,	1	65
ULYSSE DEON, Tanner, Sens, France,		Jan., 1887,	1	51

HEMP, &c.

LAWRENCE ROPE WORKS, Brooklyn, N. Y.,	1st order,	July, 1879,	2	250
do do do	2d do	Aug., 1886,		
L. WATERBURY & CO., Rope, Brooklyn, N. Y.,		Jan., 1880,	4	350
W. O. DAVEY & SONS, Oakum, Jersey City, N. J.,	1st do	Feb., 1880,	3	300
do do	2d do	Feb., 1881,		
R. J. PATRULIO, Hemp, Progreso, Mexico,		Jan., 1879,	1	60
F. STEWART SANDEMAN, Jute Mill, Dundee, Scotland,		Aug., 1883,	1	136
JAMES R. CAIRD, Flax and Jute, Dundee, Scotland,		June, 1887,	2	272
THOS. BRIGGS, Salford, England,		Nov., 1885,	1	124

LUMBER AND WOOD WORKING.

EAGLE SQUARE MFG. CO., So. Shaftsbury, Vt.,		Sept., 1883,	2	184
WOONSOCKET SPOOL & BOBBIN CO., Woonsocket, R. I.,		April, 1885,	2	146
U. S. VULCANIZING WOOD & LUMBER CO., New York,		Mar., 1882,	2	150
NEW YORK LUMBER & WOOD WORKING CO., New York City,		April, 1883,	2	165
HARDY & VOORHEES, Planing Mill, Brooklyn, N. Y.,		Jan., 1881,	1	100
ANDRESEN BLATT FOLDING BED CO., Brooklyn, N. Y.,		Jan., 1883,	1	82
WHITE, POTTER & PAIGE MFG. CO., Mouldings, Brooklyn, N.Y.,		May, 1883,	2	122
S. D. KENDRICK, Saw Mill, Glens Falls, N. Y.,		May, 1887,	1	51
HALL & GARRISON, Philadelphia, Pa.,		April, 1882,	2	150
ALBERT STOVER, Kintnersville, Pa.,		Aug., 1881,	1	40
WASHBURN & ZERFASS, Planing Mill, Scranton, Pa.,		Feb., 1884,	1	61
J. E. PATTERSON & CO., Planing Mill, etc., Pittston, Pa.,		Sept., 1885,	2	208
KIMBALL, TYLER & CO., Barrel Staves, etc., Baltimore, Md.,		Mar., 1882,	1	82
E. W. HORSTMEIER & SON, Baltimore, Md.,		Feb., 1883,	1	146
BRUMBY & BRO., Marietta, Ga.,		Jan., 1882,	1	50
PINNEO & DANIELS, Dayton, O.,		Nov., 1881,	2	200
DELPHI PLANING MILL & HOOP CO., Delphi, Ind.,		Jan., 1883,	1	61
SOUTH BEND TOY MFG. CO., South Bend, Ind.,	1st order,	Mar., 1884,	2	197
do do do	2d do,	Dec., 1887,		

		Boilers.	H. P.
WABASH SCHOOL FURNITURE CO., Wabash, Ind.,	Mar., 1884,	1	125
INDIANA FURNITURE MFG. CO., Connersville, Ind.,	July, 1885,	2	146
DODGE MFG. CO., Pulleys, etc., Mishawaka, Ind.,	June, 1888,	2	272
V. BEALE CO., Cobden, Ill.,	May., 1883,	1	71
BAUERLE & STARK. Sewing Mach. Furniture, Chicago, Ill.,	Jan., 1885,	1	136
R. G. PETERS, Saw Mill, Manistee, Mich.,	Oct., 1881,	2	500
MARINE CITY STAVE CO., Marine City, Mich.,	June, 1883,	2	200
SAGINAW CHAIR CO., Saginaw, Mich.,	Feb., 1884,	1	250
CHESBROUGH BROS., Saw Mill, Taquemenaw River, Mich.,	May, 1884,	3	312
ST. LOUIS REFRIGERATOR & WOODEN GUTTER CO., St. Louis, Mo.,	Aug., 1887,	1	240
FORT MADISON CHAIR CO., Fort Madison, Iowa,	April, 1882,	1	125
MANN BROTHERS, Milwaukee, Wis.,	Aug., 1882,	1	60
SHEBOYGAN MFG. CO., Sheboygan, Wis.,	Mar., 1883,	1	208
CROCKER CHAIR CO., Sheboygan, Wis.,	May, 1882,	1	128
FROST PETERSON VENEER SEAT CO., Sheboygan, Wis.,	May, 1883,	2	125
PAINE LUMBER CO., Oshkosh, Wis.,	Feb., 1884,	2	416
BROWNLEE & CO., City Saw Mill, Glasgow, Scotland,	Jan., 1884,	1	216
ALEX. McEWEN, Saw Mill, Wick, Scotland,	Mar., 1886,	1	146
MARCUS MOXHAM & CO., Saw Mills, Swansea, So. Wales,	Mar., 1885,	1	104
RAVERDEAU, ALLAIRE ET CIE, Romilly, France,	April, 1886,	1	51
MONTREUIL SAW MILL, Rouen, France,	April, 1886,	1	40
MONTREUIL & CO., Saw Mill, Petit-Quevilly, France,	May, 1888,	1	32

WATER WORKS.

WESTERLY WATER WORKS, Westerly, R. I.,	July, 1886,	2	90
PERTH AMBOY WATER CO., Perth Amboy, N. J.,	Aug., 1881,	2	130
PENNSYLVANIA R. R. CO., Philadelphia, Pa.,	Sept., 1882,	1	60
LACKAWANNA IRON & COAL CO., Water Works, Scranton, Pa., 1st order,	Mar., 1883,	3	312
do do do 2d do	Jan., 1887,		
LANCASTER WATER WORKS, Lancaster, Pa.,	Oct., 1887,	4	416
GREENSBORO WATER WORKS, Greensboro, N. C.,	Feb., 1888,	1	45
ELYTON LAND CO., Birmingham, Ala., 1st order,	July, 1881,	2	152
do do 2d do	May, 1882,		
BESSEMER LAND & IMPROVEMENT CO., Bessemer, Ala.,	Jan., 1888,	2	90
CENTRAL KENTUCKY LUNATIC ASYLUM, Anchorage, Ky.,	Nov., 1879,	1	110
JOLIET WATER WORKS, Joliet, Ill., 1st order,	Mar., 1881,	3	132
do do 2d do	June, 1882,		
CARTHAGE WATER WORKS CO., Carthage, Mo.,	Sept., 1881,	2	120
RED OAK WATER WORKS, Red Oak, Iowa,	Aug., 1883,	1	61
PASADENA LAND & WATER CO., Pasadena, Cal.,	Oct., 1882,	1	43
VISITACION WATER CO., San Francisco, Cal., 1st order,	April, 1883,	2	101
do do do 2d do	April, 1885,		
SPRING VALLEY WATER WORKS, San Francisco, Cal.,	Mar., 1886,	1	136
MEXBROUGH WATER WORKS, York, England,	May, 1886,	2	30
BOURNEMOUTH WATER WORKS, Bournemouth, Eng., 1st order,	Aug., 1886,	2	193
do do 2d do	Nov., 1887,		
KENT WATER WORKS. Wilmington, England.	Mar., 1886,	4	320
WEST SURREY WATER WORKS, Walton-on-Thames, England,	Mar., 1887,	2	168
EAST LONDON WATER WORKS CO., Waltham Abbey, England, April, 1887,		4	372
do do do Aug., 1887,			
SOUTHWARK & VAUXHALL WATER WORKS CO., London, Eng.	Mar., 1887,	4	336
PIMLICO WATER WORKS, London, England,	Nov., 1887,	1	108
PERNAMBUCO WATER WORKS, Pernambuco, Brazil,	June, 1885,	3	222

SEWING MACHINES.

THE SINGER M'F'G CO., New York, 1st order,	Dec., 1871,	16	1677
do do 9th do	May, 1886,		
do Elizabethport, N. J., 1st do	May, 1872,	20	2162
do do 9th do	Nov., 1887,		
do South Bend, Ind., 1st do	Sept., 1871,	8	1110
do do 6th do	July, 1881,		
do Cairo, Ill.,	June, 1881,	4	292
do Montreal, Canada, 1st do	———	3	217
do do 2d do	Mar., 1887,		
do Glasgow, Scotland, 1st do	Aug., 1882,	15	2013
do do 7th do	Oct., 1886,		
Grand Total, 34 orders, - -		66	7371
WHITE SEWING MACHINE CO., Cleveland, Ohio,	Dec., 1880,	2	200
WHITEHILL M'F'G CO., Milwaukee, Wis.,	June, 1881,	2	146
MELONE SEWING MACHINE CO., Chillicothe, Ohio,	Feb., 1883,	1	73

IRON WORKS.

TROY IRON & STEEL CO., Troy, N. Y., 1st order,	Nov., 1885,	12	1786
do do 3d do	Mar., 1888,		
W. AMES & CO., Jersey City, N. J.,	Nov., 1884,	1	240
TRENTON IRON CO., Trenton, N. J., 1st order,	Jan., 1880,	6	420
do do 4th do	June, 1882,		
NEW JERSEY STEEL & IRON CO., Trenton, N. J.,	Dec., 1885,	1	208
AMERICAN SHEET IRON WORKS, Phillipsburg, N. J.,	Mar., 1882,	1	73
DELAWARE ROLLING MILL, Phillipsburg, N. J.,	June, 1882,	1	82
HUGHES & PATTERSON, Philadelphia, Pa.,	Jan., 1886,	2	208
GORDON, STROBEL & LAUREAU. L'd, Philadelphia, Pa., 8 orders, 1886-8,		35	4390
MIDVALE STEEL CO., Nicetown, Philadelphia, Pa.,	Dec., 1887,	2	272
MARSHALL BROS. & CO., Newport, Pa.,	June, 1888,	2	272
CATASAUQUA MFG. CO., Catasauqua, Pa., 1st order,	July, 1881,	2	202
do do 2d do	Feb., 1883,		
PENCOYD IRON WORKS, Pencoyd, Pa., 1st do	April, 1881,	12	1824
do do 4th do	June, 1887,		
CHICKIES IRON CO., Chickies, Pa., 1st order,	Aug., 1887,	4	512
do do 2d do	Apr., 1888,		
PENNSYLVANIA STEEL CO., Steelton, Pa., 1st do	Mar., 1880,	3	540
do do 2d do	Dec., 1884,		
do Sparrow Point, Md.,	June, 1887,	16	3840
LONGMEAD IRON WORKS, Conshohocken, Pa., 1st do	April, 1882,	4	241
do do 2d do	Jan., 1887,		

			Boilers.	H. P.
ROBESONIA IRON CO., (L'd.) Robesonia, Pa.,		Nov., 1885,	2	480
AMERICAN TUBE & IRON CO., Middletown, Pa.,		Jan., 1888,	1	51
IOWA BARB WIRE CO., Allentown, Pa.,		Sept., 1886,	4	624
COLUMBIA ROLLING MILL CO . Vesta Furnace, Watts, Pa.,		Feb., 1887,	1	136
POTTSVILLE IRON & STEEL CO., Pottsville, Pa.,	1st order,	Aug., 1884,	3	350
do do do	2d do	Nov., 1885,		
MAHONING ROLLING MILL CO., Danville, Pa.,	1st do	Jan., 1887,	2	250
do do do	2d do	Feb., 1887,		
McCORMICK & CO., Paxton Furnaces, Harrisburg, Pa.,		Oct., 1884,	2	416
LOCHIEL ROLLING MILL CO., Harrisburg, Pa.,		Oct , 1884,	2	416
BIRD COLEMAN FURNACES, Cornwall, Pa.,	1st do	Jan., 1886,	8	1260
do do do	3d do	Feb., 1888,		
LEBANON FURNACES, Lebanon, Pa.,	1st do	June, 1885,	4	970
do do	2d do	June, 1886,		
J. & R. MEILY, Lebanon, Pa.,		Feb., 1887,	2	208
LICKDALE IRON CO., Lickdale, Pa.,		Feb., 1887,	3	450
CAMBRIA IRON CO., Johnstown, Pa.,	1st order,	Feb., 1883,	6	896
do do	3d do	Dec., 1885,		
PITTSBURGH STEEL CASTING CO., Pittsburgh, Pa.,		Nov., 1883,	2	416
LUCY FURNACES, Pittsburgh, Pa.,		Nov., 1883,	4	832
OLIVER & ROBERTS WIRE CO. (L'd.), Pittsburgh, Pa.,	1st do	Oct., 1882,	8	1664
do do do	3d do	Aug., 1884,		
CARNEGIE BROS. & CO. (L'd), Pittsburgh, Pa.,		April, 1884,	2	416
THE HARTMAN STEEL CO., (L'd) Beaver Falls, Pa.,	1st do	Oct., 1882,	4	544
do do	2d do	April, 1883,		
NATIONAL TUBE WORKS CO., McKeesport, Pa.,		Mar., 1887,	1	156
McCULLOUGH IRON CO., Wilmington, Del.,	1st do	Jan., 1874,	14	700
do do	4th do	Feb., 1882,		
do North East, Md.,	1st do	Nov., 1880,	4	308
do do	4th do	Nov., 1883,		
do Carbon Station, Md.,	1st do	April, 1884,	1	45
OLD DOMINION IRON & NAIL WORKS CO., Richmond, Va.,	1st order,	Oct., 1886,	3	408
do do	2d do	April, 1888,		
U. S. NAVY YARD, Washington, D. C.,	1st do	Nov., 1885,	7	1248
do do	2d do	May, 1888,		
do Norfolk, Va.,		April, 1887,	3	183
D. S. COOK, Princess Furnace, Glen Wilton, Va.,		June, 1887,	2	312
TENNESSEE COAL, IRON & R. R. CO., So. Pittsburgh, Tenn.,		May, 1887,	4	624
NASHVILLE IRON, STEEL & CHARCOAL CO., W. Nashville, Tenn..		Mar., 1887,	4	480
CHEROKEE IRON CO., Cedartown, Ga.,		Feb., 1886,	2	480
WOODWARD IRON CO., Woodward, Ala.,	1st order,	Sept., 1884,	8	978
do do	3d do	Jan., 1888,		
ALABAMA & TENN. COAL & IRON CO., Sheffield, Ala.,		Feb., 1887,	12	1872
GADSDEN ALABAMA FURNACE CO., Gadsden, Ala.,		Mar., 1887,	4	624
DECATUR LAND, IMP'V'T & FURNACE CO., Decatur. Ala.,		April, 1887,	4	292
SLOSS STEEL & IRON CO., North Birmingham, Ala.,		Mar., 1887,	8	1248
COLUMBUS STEEL CO., Columbus, Ohio,		June, 1886,	4	480
GLOBE NAIL CO., Boston, Mass.,		May, 1880,	2	200
TURNER & SEYMOUR MFG. CO., Torrington, Conn.,	1st order,	April, 1880,	2	100
do do do	2d do	Nov., 1881,		
T. SHRIVER & CO., New York,		April, 1882,	1	45
PHŒNIX HORSE SHOE CO., Poughkeepsie, N. Y.,		June, 1888,	1	146
SWEET'S MFG. CO., Syracuse, N. Y.,	1st do	Mar., 1881,	4	344
do do	4th do	May, 1883,		
W. H. & G. W. ALLEN, Philadelphia, Pa.,		April, 1882,	2	100
McDANIEL & HARVEY CO., Philadelphia, Pa.,		June, 1882,	1	100
DANVILLE STOVE & MFG. CO., Danville, Pa.,		Oct., 1887,	1	104
JAS. E. THOMAS, Newark, O.,		Aug., 1882,	1	50
UNION FOUNDRY & CAR WHEEL WORKS, Pullman, Ill.,		July, 1881,	1	60
FREEPORT MALLEABLE IRON CO., Freeport, Ill.,		Sept., 1881,	1	60
M. LASSIG, Bridge Builder, Chicago, Ill.,	1st order,	Jan., 1883,	4	530
do do do	3d do	Sept., 1887,		
MASON & DAVIS CO., Chicago, Ill.,		May, 1881,	1	73
KANSAS CITY BRIDGE & IRON CO., Kansas City, Mo.,		April, 1886,	1	92
GOVERNMENT MACHINE WORKS, Boyaca, U. S. C.,	1st order,	Feb., 1880,	6	220
do do do	2d do	Aug., 1880,		
DAVID COLVILLE & SONS, Motherwell, Scotland,	1st do	Mar., 1883,	17	1996
do do	3d do	Apr., 1888,		
STEEL CO. OF SCOTLAND, Blochairn, Scotland,	1st do	Mar., 1883,	4	697
do do	3d do	Feb., 1887,		
do Newton, Scotland,	1st do	Oct., 1884,	6	808
do do	2d do	July, 1885,		
WOODSIDE STEEL & IRON CO., Coatbridge, Scotland,	1st do	April, 1883,	2	186
do do do	2d do	Oct., 1886,		
ARROL BROS., Glasgow, Scotland,		April, 1883,	2	146
JAMES EADIE & SONS, Rutherglen, Scotland,		May, 1883,	1	64
JAMES MENZIES & CO., Glasgow, Scotland,		Oct., 1883,	1	104
THE CARRON CO., Falkirk, Scotland,		Dec., 1883,	2	416
J. & J. BOYDE, Shettleston, Scotland,	1st order.	Dec., 1883,	2	208
do do	2d do	Oct., 1887,		
THOS. BOLTON & SONS, Smelters, Birmingham, England,			6	748
do do Widness, Scotland,	4 orders,			
do do Oakmoor, England,				
MILLER & CO., Edinburgh, Scotland,	1st order,	Jan., 1885,	2	240
do do do	2d do	Mar., 1886,		
BRADLEY & CRAVEN, Founders, Wakefield, England,		Dec. 1887,	1	108
SOCIETA INDUSTRIALE NAPOLETANA, Naples, Italy,		July, 1885,	1	40
SOCIÉTÉ INDUSTRIELLE ET COMMERCIALE DE METAUX, Livourne, Italy,		July, 1886,	7	644

AGRICULTURAL MACHINERY.

WALTER A. WOOD M. & R. M. CO., Hoosick Falls, N.Y.,	1st order,	Sept., 1882,	3	360
do do	2d do	Aug., 1883,		
THE WHITMAN & BARNES MFG. CO., Syracuse, N. Y.,		May, 1883,	3	408
PITTS AGRICULTURAL WORKS. Buffalo, N. Y.,		Oct.. 1884,	2	102
SHEBLE & FISHER, Fork Mfrs., Philadelphia, Pa.,		April, 1881,	2	120
WHITELEY, FASSLER & KELLEY CO., Springfield, O.,		Mar., 1881,	4	400
CHAMPION KNIFE & BAR CO., Springfield, O.,		Nov., 1880,	2	300
P. P. MAST & CO., Springfield, O.,		May, 1880,	1	85
THE SPRINGFIELD ENGINE & THRESHER CO., Springfield, O.,		Sept., 1880,	1	85
WARDER, BUSHNELL & GLESSNER CO., Springfield, O.,	1st order,	Oct., 1882,	6	650
do do do	3d do	April, 1887,		
HOOSIER DRILL CO., Richmond, Ind.,		Mar., 1882,	2	150
ECONOMIST PLOW CO., South Bend, Ind.,		Dec., 1882,	1	146

			Boilers.	H. P.
SOUTH BEND IRON WORKS, Plows, So. Bend, Ind.,	1st do	Sept., 1875,	4	600
do do	3d do	Mar., 1888,		
McCORMICK HARVESTING MACHINE CO., Chicago, Ill.,		Aug., 1884,	4	480
MADISON PLOW CO., Madison, Wis.,		Mar., 1882,	2	208

MACHINE SHOPS AND MANUFACTURERS.

DALZELL AXLE CO., South Egremont, Mass.,		Mar., 1887,	1	122
NICHOLSON FILE WORKS, Providence, R. I.,		Aug., 1881,	1	104
E. JENCKES MFG. CO., Pawtucket, R. I.,		Mar., 1887,	2	240
STANDARD MACHINERY CO., Mystic River, Conn.,		Sept., 1881,	1	60
UNION METALLIC CARTRIDGE CO., Bridgeport, Conn.,		Mar., 1884,	3	276
EXCELSIOR NEEDLE CO., Torrington, Conn.,		June, 1886,	1	61
BROWN COTTON GIN CO., New London, Conn.,		Oct., 1887,	1	104
LALANCE & GROSJEAN MFG. CO., Tinware, Whitestone, L. I., N. Y.,		Sept., 1882,	1	73
PORT CHESTER BOLT & NUT CO., Port Chester, N. Y.,		July, 1882,	1	50
S. S. HEPWORTH & CO., Yonkers, N. Y.,		June, 1882,	1	104
WHEELER, MADDEN & CLEMSEN MFG. CO., Middletown, N. Y.,		May, 1883,	2	244
SCHENECTADY LOCOMOTIVE WORKS, Schenectady, N. Y.,		Feb., 1888,	1	122
E. C. STEARNS & CO., Hardware, Syracuse, N. Y.,		Mar., 1882,	1	50
FRANCIS AXE CO., Buffalo, N. Y.,	1st order,	April, 1882,	3	197
do do	3d do	Dec., 1883,		
A. H. McNEAL, Pipe Foundry, Burlington, N. J.,		Sept., 1884,	1	104
FAYETTE R. PLUMB, Cutlery, Philadelphia, Pa.,		April, 1881,	2	184
H. W. BUTTERWORTH & SONS, Philadelphia, Pa.,		June, 1881,	1	100
GEO. V. CRESSON, Shafting, Philadelphia, Pa.,		Feb., 1880,	1	50
GORDON, STROBEL & LAUREAU, L'd., Philadelphia, Pa.,		Jan., 1887,	1	45
READING BOLT & NUT WORKS, Reading, Pa.,		Sept., 1886,	1	82
WESTINGHOUSE AIR BRAKE CO., Pittsburgh, Pa.,	1st order,	Oct., 1883,	2	184
do do	2d do	June, 1888,		
BLACK & GERMER, Stoves, Erie, Pa.,		Oct., 1883,	1	92
HARLAN & HOLLINGSWORTH CO., Iron Ships, Wilmington, Del.,		Dec., 1871,	2	100
THE J. MORTON POOLE CO., Wilmington, Del.,		Oct., 1873,	2	100
J. A. FAY & CO., Cincinnati, O.,		Oct., 1881,	2	150
CINCINNATI CORRUGATING CO., Cincinnati, O.,		Feb., 1884,	1	73
GORDON & MAXWELL CO., Pumps, Hamilton, Ohio,		Feb., 1887,	1	45
FLINT & WALLING MFG. CO., Wind Engines, Kendallville, Ind.,		Feb., 1884,	1	164
M. C. HENLEY, Skates, Richmond, Ind.,		April, 1884,	1	73
SOUTH BEND PUMP CO., South Bend., Ind.,		Oct., 1886,	1	61
FIELDHOUSE & DUTCHER MFG. CO., Chicago, Ill.,		Feb., 1882,	1	75
TATUM & BOWEN, San Francisco, Cal.,		April, 1882,	1	60
HOLBROOK, MERRILL & STETSON, San Francisco, Cal.,		April, 1886,	1	25
JUDSON MFG. CO., San Francisco, Cal.,	1st order,	Mar., 1883,	3	352
do do do	2d do	Feb., 1887,		
KENNEDY'S PAT. WATER METER CO., Kilmarnock, Scotland,		Mar., 1883,	1	51
THE GLENFIELD CO., Kilmarnock, Scotland,		Aug., 1883,	1	72
THOMAS SHANKS & CO., Johnstone, Scotland,		Aug., 1883,	1	104
JAMES KEITH, Arbroath, Scotland,		Dec., 1885,	1	20
JOHN DEWRANCE & CO., London, England,		April, 1886,	1	10
T. COULTHARD & CO., Spinning Machinery, Preston, England,		April, 1887,	2	280
L. WHITAKER & SONS, Crane Railroad Mill, Haslingden, England,		May, 1887,	1	140
GEO. RICHARD & CO., L't'd, Broadheath, near Manchester, Eng.,		Oct., 1887,	1	122
MERMIER & CO., Firearms, St. Etienne, France,		Dec., 1886,	1	120
S. LAMBERT ET FILS, Tinware, Paris, France,		Mar., 1887,	1	69
BAUER & SCHAURTE, Bolt & Nut Works, Neuss, Germany,		April, 1887,	1	136

BRASS WORKS, ETC.

WALLACE & SONS, Ansonia, Conn.,	1st order,	June, 1878,	6	520
do do	2d do	Feb., 1881,		
THE SETH THOMAS CLOCK CO., Thomaston, Conn.,		June, 1880,	1	125
THE SCOVILLE MFG. CO., Waterbury, Conn.,	1st do	Nov., 1879,	4	500
do do	2d do	July, 1882,		
BENEDICT & BURNHAM MFG. CO., Waterbury, Conn.,	1st order,	June, 1882,	2	406
do do	2d do	May, 1886,		
ASHCROFT MFG. CO., Bridgeport, Conn,		Dec., 1885,	1	73
CONSOLIDATED SAFETY VALVE CO., Bridgeport, Conn.,		Dec., 1885,	1	30
HOOLE MFG. CO., Brass Checks, etc.,		Feb., 1882,	1	50
E. P. GLEASON M'F'G CO., Gas Fixtures, New York,		Jan., 1883,	1	122
ANSONIA CLOCK CO., Brooklyn, N. Y.,	1st order,	Jan., 1879,	4	414
do do	2d do	Dec., 1884,		
ROSS BROS. & WHISTLER, Wabash, Ind.,		Jan., 1883,	1	61
CHAS. BARWELL, Copper Tube Mill, Birmingham, Eng.,		June, 1887,	1	85
M. CLIN, Brassworks, Paris, France,		May, 1885,	2	102
COPPER & BRASS WORKS MFG. CO., Koltschugine, near Moscow, Russia,		Jan., 1885,	3	219

CAR AND WAGON MANUFACTURERS.

H. D. SMITH & CO., Carriages, Plantville, Conn.,		Oct., 1881,	1	75
CORTLAND WAGON CO., Cortland, N. Y.,		Sept., 1881,	1	82
LEHIGH CAR WHEEL & AXLE Co., Catasauqua, Pa.,		Dec., 1881,	2	256
ERIE CAR WORKS (Lim.), Erie, Pa.,		Sept., 1882,	1	120
THE JACKSON & SHARP CO., Wilmington, Del.,	1st order,	Jan., 1881,	5	459
do do	3d do	Aug., 1884,		
PETERS DASH CO., Columbus, Ohio,		Sept., 1881,	1	50
COLUMBUS BUGGY CO., Columbus, Ohio,	1st do	Nov., 1882,	7	827
do do	4th do	June, 1887,		
LAFAYETTE CAR WORKS, Lafayette, Ind.,		Jan., 1883,	2	250
STUDEBAKER BROS. MFG. CO., South Bend., Ind.,	1st order,	Aug, 1872,	10	1080
do do do	4th do	Feb., 1884,		
do do Chicago, Ill.,	5th do	Oct., 1885,	4	400
PULLMAN PALACE CAR CO., Pullman, Ill.,		Sept., 1881,	8	1000
RACINE WAGON & CARRIAGE CO., Racine, Wis.,		Aug., 1882,	1	125
JAS. L. CLARKE & SON, Carriages, Oshkosh, Wis.,		May, 1881,	1	107
GOVERNMENT RAILWAY SHOPS, Dunedin, New Zealand,		Dec., 1878,	4	200
do do Christ Church, do		Jan., 1879,	3	175

RAILROADS.

PENN. R. R. CAR SHOPS, Hoboken, N. J.,		May, 1883,	2	102
SEABOARD & ROANOKE R. R., Portsmouth, Va.,		Jan., 1888,	2	146
L. E. & W. R. R., Lima, Ohio,		Sept. 1880,	2	100

			Boilers.	H. P.
TOLEDO & OHIO CENTRAL R. R., Bucyrus, Ohio,		Oct., 1880,	2	100
F. & P. M. R. R. CAR SHOPS, East Saginaw, Mich.,		April, 1881,	2	500
C., B. & Q. R. R., Burlington, Iowa,		Sept., 1881,	4	368
ST. PAUL & N'TH'N PACIFIC R.R., Como Shops, Minn.,	1st order,	July, 1885,	6	624
do do do	2d do	April, 1887,		
MINNESOTA & N. W. R. R., St. Paul, Minn.,	1st order,	Oct., 1886,	4	408
do do	2d do	Oct., 1887,		
NORTHERN PACIFIC TERMINAL CO., Albina Shops, Oregon,		Feb., 1884,	6	720
COMPAGNIE DES TRAMWAYS DU DEPARTEMENT DU NORD, Roubaix, France,		June, 1886,	3	135
COMPAGNIE DES OMNIBUS ET TRAMWAY, Lyons, France,		Dec. 1887,	2	90
LIMA & ORRYA RAILWAY CO., Callao, Peru, S. A.,		July, 1871,	3	115
CHIMBOTE RAILWAY CO., Chimbote, Peru, S. A.,		April, 1872,	2	50
MOSCOW KURSK RAILROAD, Moscow, Russia,	1st order,	Aug., 1886,	2	134
do do do	2d do	Sept., 1886,		

MINING.

BIGELOW BLUE STONE WORKS, Maiden Lane, N. Y.		Jan., 1883,	1	122
NEW JERSEY IRON MINING CO., Port Oram, N. J.,		Sept., 1886,	2	150
J. C. HAYDON & CO., Janesville, Pa.,		Jan., 1883,	1	61
LEHIGH COAL & NAVIGATION CO., Lansford, Pa.,	1st order,	June, 1886,	14	1456
do do Nesquehoning, Pa.,	4th do	June, 1888,		
J. LANGDON & CO, Inc'd, Shamokin, Pa.,		Mar., 1887,	2	208
MINERAL RAILROAD & MINING CO., Shamokin, Pa.,	1st order,	May, 1887,	6	720
do do do	2d do	May, 1888,		
NEW HOOVER HILL GOLD MINING CO., Randolph Co., N. C.,		April, 1881,	1	51
N. C. GOLD MINING & REDUCTION CO, Salisbury, N. C.,		Aug., 1882,	2	100
WM A. SWEET, Catawba, N. C.,		Sept., 1880,	1	75
CONGLOMERATE MIN'G CO., Eagle Harbor, Mich.,	1st order,	Feb., 1881,	12	1974
do do do	5th do	Mar., 1883,		
SILVER CLIFF MINING CO., Colorado,	1st order,	Aug., 1879,	4	400
do do	2d do	May, 1880,		
GOOD ENOUGH MINING CO., Colorado,		Mar., 1880,	1	100
PLATA VERDE SILVER MINING CO., Colorado,		Nov., 1879,	2	200
H. L. BRIDGEMAN, Assayer, Pueblo, Colorado,		May, 1880,	1	60
RANDOLPH & CO., Central City, Colorado,		May, 1881,	1	53
IRON SILVER MINING CO., Leadville, Colorado,		May, 1882,	3	225
MOULTON MINING CO., Butte City, Montana,	1st do	Nov., 1880,	5	375
do do	3d do	Sept., 1881,		
ORIGINAL BUTTE MINING CO., Butte City, Montana,		April, 1881,	2	150
ALTA MONTANA CO., Wycks, Montana,		April, 1881,	2	150
LEGAL TENDER MINING CO., Clancy, Montana,		April, 1881,	1	75
NATIONAL MINING & EXPLORING CO., Helena, Montana,		May, 1876,	1	75
BIG LODE MINING CO , Idaho,		Feb., 1883,	1	82
GERMANIA LEAD WORKS, Salt Lake City, Utah,		May, 1882,	2	166
EMPIRE MINING CO., Park City, Utah,	1st order,	Oct., 1879,	8	600
do do	3d do	Jan., 1880,		
ONTARIO SILVER MINING CO., Park City, Utah,	1st do	Jan., 1880,	3	270
do do	2d do	Jan., 1880,		
MINERAL POINT TUNNEL CO., Utah,	1st do	Mar., 1878,	2	60
do do	2d. do	June, 1879,		
HORN SILVER MINING CO., Utah,		Nov., 1879,	2	120
G. BILLING, Smelting Works, Socorro, N. M.,		April, 1883,	2	102
ESTACA DE GUADALUPE DE LOS REYES, Mexico,	1st do	Dec., 1878,	4	245
do do	2d do	Mar., 1880,		
N. Y. & CHIHUAHUA MINING CO., Mexico,		Mar., 1880,	3	195
CORRALITOS MINING CO., Chihuaha, Mexico,		Jan., 1881,	1	50
GUERRA GOLD & SILVER MINING CO., Mazatlan, Mexico,		June, 1885,	1	50
CANDELERIA PUMPING SYNDICATE of N.Y., Soledad, Mexico,		Feb., 1885,	2	146
NEGOCIACION MINERA INNERNACIONAL, Canitas, Mexico,		Nov., 1885,	1	61
UNION CATORCINA MINING CO., San Lusi de Potosi, Mexico,		Sept., 1873,	2	100
VALLECILLO MINING CO., Mexico,		Sept., 1881,	1	50
THE ACADIA COAL CO., Stellarton, N. S.,	1st order,	July, 1884,	5	708
do do	3d do	Jan., 1888,		
BENT COLLIERY, Bothwell, Scotland,	1st do	May, 1883,	4	480
do Hamilton, do	2d do	Dec., 1884,		
MARK HURLL, Coal Master, High Blantyre, Scotland,		Nov., 1883,	2	240
THE LANEMARK COAL CO., New Cunnock, Scotland,		April, 1886,	2	240
COMPANIA "LA CRUZ," Linares, Spain,		Dec., 1886,	2	95
CHILETE MINING CO., Callao, Peru, S. A.,		Dec., 1874,	3	150
GIANT'S DEN MINING CO., Australia,		Oct., 1883,	1	73
M. KENNEDY, Colliery, Greymouth, New Zealand,		Oct., 1887,	2	248

EXPORT AND COMMISSION HOUSES.

WALTON W. EVANS, Civil Engineer, New York,	1st order,	July, 1871,	11	540
do do	2d do	Sept., 1878,		
JOSEPH E. SPINNEY, Merchant, New York,		Dec., 1878,	5	360
CAMACHO & VEMGOECHEA, Merchants, New York,	1st do	Jan., 1880,	3	220
do do	2d do	Aug., 1880,		
J. FOGERTY, New York,		Aug., 1879,	1	75
MOSES TAYLOR & CO., New York,		Mar., 1883,	2	146
BECKETT & McDOWELL MFG. CO., New York,	1st do	Mar., 1880,	5	246
do do	4th do	Oct., 1883,		
FRED'K PROBST & CO., Merchants, New York,	1st do	Nov., 1878,	9	571
do do	5th do	Feb., 1887,		
HENRY J. DAVISON, New York,	1st do	Feb., 1882,	3	243
do do	2d do	Jan., 1884,		
R. H. ALLEN, Merchant, New York,		June, 1881,	2	150
BEHR & STEINER, Merchants, New York,		Sept., 1881,	1	50
G. REYNAUD, New York, for Cuba,	1st order,	June, 1882,	4	367
do do	4th do	July, 1885,		
MOTLEY & STIRLING, Merchants, New York,		Mar., 1883,	1	104
A. ARANGO & CO., Merchants, New York,		Aug., 1882,	2	208
MAITLAND, PHELPS & CO., New York,	1st do	Oct., 1881,	8	784
do do	7th do	Feb., 1885,		
J. CRICHTON, Valparaiso, Chili,		Jan., 1882,	1	50
COOMBS, CROSBY & EDDY, New York, for Mexico,		July, 1881,	1	30
SORZANO & CO., Merchants, New York,	1st order,	July, 1881,	3	442
do do	2d do	Mar., 1883,		
FERNANDEZ & CASTILLO, New York,		Feb., 1883,	1	104
H. A. VATABLE & SON, New York,		Oct., 1882,	1	104
MOSLE BROS., New York, for Cuba,	1st do	June, 1883,	14	2440
do do	8th do	Sept., 1886,		

			Boilers.	H. P.
ROBERT DEELEY & CO., New York,		May, 1883,	4	416
E. L. BECERRA'S NEPHEW & CO., New York,		Jan., 1884,	1	104
BUTLER, McDONALD & CO., New York,	1st do	Feb., 1884,	4	480
do do	2d do	Sept., 1885,		
COLWELL IRON WORKS, New York, for Louisiana,	1st do	Mar., 1879,	4	400
do do	2d do	Nov., 1879,		
do do for Mexico,	3d do	Aug., 1884,	1	122
J. L. MOTT IRON WORKS, New York, for Mexico,		Feb., 1884,	1	15
AUG. A. GOUBERT, New York, for Cuba,	1st do	Sept., 1884,	3	246
do do	2d do	Aug., 1885,		
CANDELERIA PUMPING SYNDICATE of N. Y., for Mexico,		Feb., 1885,	2	146
M. ECHEVERRIA & CO., New York, for Mexico,		Oct., 1885,	1	75
THEO. HERRMANN, New York, for Mexico,		Oct., 1885,	1	61
M. COMACHO ROLDAN & NEPHEW, N. Y., for Mexico,		June, 1887,	1	122
GEO. BRUCE'S SON & CO., New York, for Mexico,	1st order,	Oct., 1887,	2	184
do do do	2d do	Dec., 1887,		
J. & G. FOWLER, New York, for Cuba,	1st do	Sept., 1887,	4	584
do do do	2d do	Dec., 1887,		
HUGH KELLY, New York, for Ceiba Hueca, W. I.,		Jan., 1888,	1	208
ROBT. McCULLOCH, Yonkers, N. Y., for Cuba,		Sept., 1886,	1	104
D. L. HOLDEN, Philadelphia, for China,		Sept., 1880,	1	60
J. ARCE & CO., City of Mexico,	1st order,	Mar., 1888,	2	91
do do	2d do	July, 1888,		
JAS. KEITH, Hydrographical Engineer, Edinburgh, Scotland,		1884-6,	8	275
BLAIR, CAMPBELL & McLEAN, Glasgow, for Costa Rica,		Feb., 1887,	1	122
ARTHUR BUTLER, London, for India,	1st order,	Aug., 1884,	14	634
do do	14th do	Jan., 1887,		
JAS. McEWAN & CO., London, for Australia,	1st do	Nov., 1884,	10	1040
do do	2d do	July, 1885,		
JAS. SIMPSON & CO., L't'd, Engineers, London, Eng.,	1st order,	June, 1885,	12	871
do do	5th do	Jan., 1888,		
WALKER BROS., London, for Ceylon,	1st order,	April, 1886,	11	251
do do	10th do	Feb., 1888,		
J. & H. GWYNNE, London, for China,		Sept., 1886,	2	146
ANDERSON BROS., London, for India,		Nov., 1886,	1	120
W. WALKER, London, for Batavia,		Nov., 1885,	1	13
A. STUART, London, for Batoum, Russia,		April, 1886,	1	104
NELSON BROS., London, England, for New Zealand,	1st order,	Mar., 1887,	2	140
do do do	2d do	Feb., 1888,		
TAKATA & CO., do for Japan,		Dec., 1887,	3	249
H. F. STANES, London, for New Zealand,		Jan., 1888,	1	104
HAMMOND & CO., do for Spain,		Oct., 1887,	1	104
DU TEMPLE & CO., Liverpool, for Asia Minor,		July, 1886,	1	82
E. GRETHER, Manchester, England, for Genoa, Italy,	1st order,	Feb., 1887,	2	34
do do do	2d do	Oct., 1887,		
ZIFFER & WALKER, do for Brazil,		Dec., 1887,	2	124
EDGAR ALLAN & CO., Sheffield, for Spain,		June, 1887,	1	30
MILLWARD, BRADBURY & CO., Liverpool, for Brazil,	1st order,	April, 1886,	6	452
do do do do	5th do	Mar, 1888,		
S. WALKER & CO., Wolverhampton, England, for Hong Kong,		Sept., 1883,	1	104
E. R. & F. TURNER, Ipswich, England, for Ceylon,		Mar., 1887,	1	20
ASA LEES & CO., L'd, Oldham, England, for Bombay,		Feb., 1888,	3	372
JOHN HENRY STEWART, Withirgton, England, for Brazil,		Mar., 1888,	1	62
FISHER & CO., Huddersfield, England, for Canada,		Mar., 1888,	1	108
LOUIS FONTAINE, La Madeleine les Lille, France,	42 orders,	1883-7,	57	8391
AMELIN & RENAUD, Paris, for Buenos Ayres,	1st order,	July, 1887,	2	50
do do do	2d do	Sept., 1887,		
ALEX. B. BARY, Moscow, Russia,	18 orders,	1883-8,	22	1321
J. S. BERGHEIM, Vienna, Austria, for Oil Wells at Garlice-Galicia,		April, 1887,	2	186
JOHN McDONALD, Townsville, N. Australia,		Sept., 1887,	1	51
LEMGRUBER & LEMGRUBER, Rio Janerio, Brazil,		May, 1888,	1	40
WALSH, LOVETT & CO., Birmingham, Eng., for the Hamalayas,		Mar., 1888,	2	102

DISTILLERS AND BREWERS.

			Boilers.	H. P.
FRED'K A. POTH, Philadelphia, Pa.,		Sept., 1883,	4	416
HANNIS DISTILLING CO., Baltimore, Md.,	1st order,	Nov., 1880,	3	420
do do	2d do	May, 1886,		
BARTHOLOMÆ & LEICHT BREWING CO., Chicago, Ill.,	1st order,	Feb., 1881,	4	324
do do	2d do	July, 1888,		
McAVOY BREWING CO., Chicago, Ill.,		June, 1882,	4	832
LION BREWERY, Detroit, Mich.,		Nov., 1885,	2	500
KONRAD SCHREIER, Brewer, Sheboygan, Wis.,		May, 1881,	1	75
PH. ZANG & CO., Brewers, Denver, Col.,		June, 1884,	1	150
SR. DON JOSE ARECHABALA, Cardenas, Cuba,		July, 1885,	1	61
SR. DON JOSE T. GUERRA, Cuautla, Morelos, Mexico,		June, 1886,	1	30
do Cuernavaca, do do		Oct., 1886,	1	51
HARMON & CO., Brewers, Uxbridge, England,		May, 1887,	1	112
W. E. & J. RIGDON, Faversham, England,		Mar., 1888,	1	130
LESAFFRE & BONDUELLA, Mareq en Barlheuil, France,		Nov., 1885,	1	93
DROULLERS-PROUVOST, Distillers, Roubaix, France,	1st order,	Dec., 1885,	2	372
do do	2d do	Jan., 1886,		
SOCIETE ANONYME LA GALLIA, Paris, France,		May, 1886,	1	51
A. & B. VAGNIEZ, Distillers, Amiens, France,	1st do	Nov., 1885,	3	417
do do	2d do	Aug., 1886,		
SCHMERZ-FRITSCH, Brewers, Orleans, France,		Oct., 1886,	1	40
G. RINCK, Brewer, St. Etienne, France,		June, 1887,	1	25
J. SCHAARSCHUH, Rummelsburg, Germany,		Mar., 1887,	1	93
WILHELMSTE BREWERY, Stralan, Germany,		May, 1887,	1	93
W. M. FOSTER, Melbourne, Australia,	1st order,	Sept., 1887,	2	90
do do	2d do	May, 1888,		

CABLE TOWAGE.

N. Y. & BROOKLYN BRIDGE, Brooklyn, New York,	1st order,	Oct., 1882,	6	624
do do	2d do	July, 1886,		
CHICAGO CITY R. R., Chicago, Ill.,		April, 1881,	4	1000
GRAND AVE. RAILWAY CO., Kansas City, Mo.,		Aug., 1886,	3	600
METROPOLITAN ST. RAILWAY CO., Kansas City, Mo.,	1st order,	Sept., 1886,	9	1800
do do	3d do	Feb., 1888,		
INTERSTATE CONSOLIDATED RAPID TRANSIT R'WAY CO., Kansas City, Mo.,		Aug., 1887,	2	400
PEOPLE'S CABLE RAILWAY CO., Kansas City, Mo.,		Aug., 1887,	3	600
MARKET ST. CABLE RAILWAY, San Francisco., Cal.,	1st order,	June, 1882,	6	1500
do do	2d do	Aug., 1887,		

		Boilers.	H. P.
PAT. CABLE TRAMWAY CORPORATION, London, Eng.,	Aug., 1883,	2	240
do Edinburgh, Scot'd,	Dec., 1886,		
STEEP GRADE CABLE TRAMWAY CO., Highgate, London,	Sept., 1884,	1	51
THE MELBOURNE TRAMWAYS, Richmond Line, Australia,	Nov., 1884,	6	1040
do Fitzroy Line, do	July, 1885,		

TOBACCO AND SNUFF.

P. LORILLARD & CO., Jersey City, N. J., 1st order,	Dec., 1881,	10	1470
do do 3d do	April, 1883,		
GEO. W. HELME CO., Helmetta, N. J., 1st do	1883,	2	122
do do 2d do	Oct., 1884,		
WILSON & McCALLAY TOBACCO CO., Middletown, O., 1st do	Sept., 1881,	2	250
do do do 2d do	July, 1885,		
WM. CLARK & SON, London, England, 1st do	April, 1884,	3	181
do do 3d do	May, 1887,		

ARTIFICIAL ICE.

SOUTHERN ICE CO., New Orleans, La.,	Sept., 1882,	2	272
TEXARKANA ICE CO., Texarkana, Texas,	Mar., 1884,	1	30
BATH PURE ICE CO. (L'd.), Bath, England,	Mar., 1886,	1	30
L. STERNE & CO. (L'd.), London, England, 1st order,	June, 1887,	3	205
do do 3d do	Apr., 1888,		

PACKERS AND CANNERS.

THE UNION STOCK YARDS CO., Sioux City, Iowa,	Sept., 1887,	4	548
MARSHALL CANNING CO., Marshalltown, Ia.,	Nov., 1880,	2	120
ARMOUR PACKING CO., Kansas City, Mo., 1st order,	Oct., 1886,	2	500
do do 2d do	Nov., 1886,		
SILLITOE & SEARES, Packers & Shippers, Manchester, England,	Aug., 1885,	1	65
W. STEVENSON, Packer, Manchester, England,	Oct., 1885,	1	85

MISCELLANEOUS.

HALLET & DAVIS CO., Pianos, Boston, Mass., 1st order,	May, 1881,	1	104
MOORE, Boiler Built over, 2d do	June, 1888,		
HEATON BUTTON FASTENER CO., Providence, R. I.,	Apr., 1888,	1	92
UNION INDIA RUBBER CO., New York,	Mar., 1882,	2	120
E. GREENFIELD'S SON & CO., Confectioners, Brooklyn, N. Y.,	Feb., 1884,	2	164
FAHYS WATCH CASE CO., Sag Harbor, N. Y.,	April, 1887,	2	146
MILLER, HALL & HARTWELL, Shirts, Troy, N. Y.,	Jan., 1883,	1	122
KREMENTZ & CO., Jewelry, Newark, N. J.,	Aug., 1884,	1	50
JOHN MOSES, Pottery, Trenton, N. J.,	Aug., 1880,	2	150
WRIGHT BROS. & CO., Umbrellas, Philadelphia, Pa.,	Dec., 1873,	1	75
NOAH BARLOW, Upholsterers' Goods, Philadelphia, Pa.,	May, 1884,	1	30
HENRY MAURER & SON., Maurers, N. J.,	Apr., 1888,	2	244
COPLAY CEMENT CO., Coplay, Pa.,	Mar., 1884,	1	104
SOCIETE DES CIMENTS FRANÇAIS ET DES PORTLAND, Boulogne-on-the-Sea, France.	Dec., 1887,	4	612

		Boilers.	H. P.
WOODLAND FIRE BRICK CO. (L'd), Woodland, Pa.,	Aug., 1884,	1	92
WISE BROS., Overalls, &c., Baltimore, Md.,	Feb., 1887,	2	102
VOGLER & GEUDTNER, Trunks, Chicago, Ill.,	July, 1881,	1	83
YOUNG & FARRELL DIAMOND STONE SAWING CO., Chicago, Ill.,	3 orders, 1882-6,	3	248
C. G. ELRICK & CO. (L'd), Comb Works, Aberdeen, Scotland,	June, 1887,	1	136
RICHARD SHEPPARD, Mill, Newchurch, England,	Jan., 1885,	1	40
CLOG SOLE FIBRE CO., Liverpool, England,	Nov., 1885,	1	138
JAMES PATTERSON & CO., Pifeford Mills, Blackley, England,	July, 1886,	1	73
BRITISH PNEUMATIC PULVERIZING CO., London, England, 1st order,	Aug., 1886,	2	80
do do do 2d do	Jan., 1887,		
THOS. CARLYLE, Buttons, Birmingham, England,	Nov., 1886,	1	51
BASTIN & LAWSON, Southampton, England,	Jan., 1887,	1	30
OUTRAM & CO., Preston, England,	Feb., 1887,	2	280
CADBURY & CO., Chocolate, Bournville, England, 1st order,	Mar., 1887,	2	186
do do do 2d do	July, 1887,		
ROBT. CHARLTON & SONS, Calenders, Manchester, England,	May, 1887,	1	156
THE COWLES SYNDICATE CO., L't'd, Aluminium, Milton, Eng.,	Oct., 1887,	2	280
W. E. CAMERON, Macclesfield, England,	Oct., 1887,	1	30
LANGWORTHY BROS., Grengate Mills, Salford, England,	Nov., 1887,	1	173
CAMBRIAN PATENT FUEL CO., Cardiff, Wales,	Dec., 1886,	1	92
BAYART, Tourcoing, France,	Nov., 1884,	1	240
BINET, PERE ET FILS, Tourcoing, France,	Jan., 1885,	1	136
EDMOND BERTRAND, Cambrai, France,	June, 1885,	2	102
A. DUPONT ET CIE., Brush Manufacturers, Beauvais, France,	Feb., 1886,	1	104
CUVIER, Clog-maker, Neuville, Ferrieres, France,	Nov., 1886,	1	51
ROUSSEL, Wick-maker, Amiens, France,	Nov., 1886,	1	20
ANTISSER FILS, Marseilles, France,	Dec., 1886,	1	136
HARDING COCKER, Lille, France,	Oct., 1887,	1	30
MARCHAND FRÈRES, Dunkirk, France,	Oct., 1887,	1	138
LOUIS GLORIEUX, Roubaix, France,	Oct., 1887,	1	166
CARRAGIO & TRINXET, Barcelona, Spain,	Oct., 1885,	2	146
GARCIA GIRONA Y CIA., Brushmakers, Barcelona, Spain,	Dec., 1885,	1	30
PERERA & PORTABELLA, Spain,	Feb., 1888,	1	122
H. GUTSCHOW, Pianos, Berlin, Germany,	Mar., 1887,	1	35
C. SCHUBERT, Berlin, Germany,	April, 1887,	1	30
STEINLEIN BROTHERS, Berlin, Germany,	Sept., 1887,	1	51
KOHLSTEDT & GRAMMBERG, Nordeney, Germany,	Jan., 1888,	1	25
PFLAUM & GERLACH, Berlin, Germany,	July, 1887,	1	26
A. EDLMANN & CO., Bologna, Italy,	Nov., 1885,	1	82
VOMVILLER & CO., Romagnano, Italy,	May, 1885,	1	208
TOSI & CO, Legnana, Italy,	Nov., 1886,	1	51
GUISEPPE PINSONI, Genoa, Italy,	Mar., 1887,	2	148
MELCHOIORRE BELLETIERI. Civita Vecchia, Italy,	June, 1887,	1	30
A. IVANOWITSCH ALEXAJEFF, Moscow, Russia, 1st order,	1883,	2	195
do do 2d do	1884,		
R. & T. ELWORTHY, Elizabethgrad, Russia,	June, 1884,	1	23
S. M. LIANASOFF, Salt Mill, Waldimiroffka, Russia,	Feb., 1885,	1	73
S. M. SHIBÆFF & CO., Batoum, Russia,	Sept., 1885,	1	51
A. W. MAKAROFF, Wadding Manufacturer, Astrakan, Russia,	July, 1886,	1	30
LA CIA. NOVA INDUSTRA, Rio de Janeiro, Brazil,	Oct., 1886,	1	35
JUAN LAMAISON, Buenos Ayres, Arg. Rep.,	Oct., 1886,	1	15
J. P. OWEN, Tea-planter, Maturata, Ceylon,	Mar., 1887,	1	20

CONTENTS.

PAGE.

Advantages of Babcock & Wilcox boilers 13
Air required for combustion 25, 27
Air and Steam. Mixtures of 37
American coals. Table of 27
Atlanta Exposition. Award of Judges at 72
Attention necessary to secure:
  Durability in boilers 49
  Economy " 47
  Safety " 47
Anti-incrustators 31
Apparatus for handling coal 52, 66
Babock & Wilcox boilers:
  Absorption of heat in 15
  Advantages of 13
  at American Institute 69
  at American Tube Works 59
  at Bemis & McAvoy Brewing Co 48
  at Boston Sugar Refinery 16
  at Brooklyn Sugar Refinery 52
  at Centennial 64, 72
  at Columbia College 54
  at Decastro & Donner Sugar Refinery 31, 34
  at Edison's Laboratory 18, 63
  at Edison Illuminating Co.'s 58, 63
  at Gambrill & Co. (Arlington Mills) 46, 71
  at Greenfield & Co.'s 30
  at Harrison, Frazier & Co.'s ..... Front, 62, 63, 70
  at Ingenio Fortuna 24
  at Kimball House 14
  at Lombard, Ayres & Co 60
  at Lucy Furnace 40, 42
  at Matthiesson & Wiechers' Sugar Refinery 6
  at Clark Mile End Thread Co 50
  at New Orleans Exposition 8
  at New York Mutual Life Insurance Co 22
  at New York Steam Co 38, 39
  at Pittsburgh Steel Castings Co 10
  at Plainfield Public School 20
  at Raritan Woolen Mills 12, 55
  at Seth Thomas Clock Co 4
  at Somerset Manufacturing Co 44
  at Standard Oil Co 26
  at "Vancorlear" Apartment House 14
  at W. C. Hamilton & Sons 32
Burning Bagasse 24
  " petroleum 26

PAGE.

Babcock & Wilcox boilers:
  Burning waste gases 40, 41, 42
  Capacity of 17, 71, 72
  Circulation of water in 15
  Cleaning 17, 47
  Construction of 11
  Cross section of 18, 32, 38, 44, 50, 54, 64
  Combustion in 13, 25
  Dryness of steam 15, 23, 59
  Durability of 15
  Efficiency of 19, 59, 71
  Erection of 11
  for iron works 40, 41, 42
  Front view ..... Frontispiece, 6, 8, 14, 16, 18, 20. 22, 24, 26, 30, 34, 36, 38, 42, 46, 48, 56, 64
  Heating surface in 13
  Joints in 11, 13, 15
  Longitudinal sections 4, 10, 11, 12, 20, 32, 39, 40, 41, 50, 52, 58, 60, 66
  Operation of 11
  Proportions of 17
  References for 73, 86
  Safety of 7, 9, 15, 41, 47, 72
  Tests of 55, 57, 59, 61, 63, 65, 67, 69, 71
  with continuous front 16
  with ornamental front 6, 8, 14, 16, 22, 34, 46, 48, 56
  with wrought-iron front 10, 14, 30
Babcock & Wilcox Economizer 28, 29
Boiler inspection. Results of 5
  " house. Plans for 32, 38, 39, 44, 50, 52, 54, 60, 62, 66
  " Tests. Rules for 23, 49, 55, 57
Boilers. Defective, proportion of, in use 5
  " Economy of 19
  " " to secure 47
  " Efficiency of 19, 25
  " Heating surface in 21
  " Horse power of 21, 59
  " Requirements of perfect 3
  " Rules for care of 47, 49
  " Safety in, importance of 5
  " " attention necessary to secure 47
  " Tests of 55, 71
Boiling by steam 37
Calorie Value of 53
Calorimeter. Construction of 23, 56

PAGE.

Calorimeter. Formula for 57, 59
Care of boilers 47, 49
Cement covering for pipes 48
Centennial award 72
  " Babock & Wilcox boilers at 64, 72
Chemicals for preventing scale 31
Chimneys 32, 33, 44, 50, 60, 62
  " Formula for 33
  " Area of 33
  " Draft of 33
  " Rules for 33
  " Table of 33
Circulation of water in boilers 5, 15
City lot. Plan for 1,000 H. P. on a 66
Coal. Table of American 27
Coal used annually 3
Color of fire at different temperatures 23
  " Effect of, on radiation 45
Combustibles. Value of different 27
Combustion 13, 27
  " Air required for 25, 27
  " in Babcock & Wilcox boilers 13
  " of smoke 13, 25
  " Temperature of 23, 27
Conducting power of various substances 45
Cotton Exposition, International, award 72
Covering for steam pipes, etc 45
Dangerous boilers 5
Defective boilers. Proportion of, in use 5
Drying by steam 37
Dry Steam 15, 23, 57, 59
Durability. Attention necessary to secure 49
Dust on tubes 17
Economy. Attention necessary to secure 47
  " in steam 19
Economizers. Fuel 29
  " Babcock & Wilcox 28, 29, 32, 44, 50, 54, 58, 60, 62, 66
Efficiency of boilers 19, 25, 72
  " of engines 19
  " of pumping machinery 19
  " of furnace 25
Emery. Charles E.:
  Formula for Calorimeter 57, 59
  Table of non-conductors 45
  " pumping machinery 19

PAGE.

Emery. Charles E.: Test at Raritan 55
Engines. Efficiency of 19
Explosions. Causes of 5
" How to provide against 7, 47
" Importance of providing against 5
" in 1880 5
Expansion. Unequal 5, 7
Evaporation. Formula for 49, 51
Evaporative efficiency of fuels 19, 27
" " of B. & W. Boilers 19, 55–71
Feed-water purifier 31
" Saving by heating 29
Felting for steam pipes, etc 45
Fire. Temperature of, color, etc 23
Fire tubes. Collection of dust in 17
Firing. Effect of different 25
Flow of steam from orifices 43
" " through pipes 43
Formula for calorimeter 47, 59
" " chimneys 33
" " evaporation 49, 51
" " flow of steam 43
Fuel 27
" American coals, table of 27
" Combustible in 27
" Economizers 29
" Evaporative efficiency of 19, 27
" Furnace should suit 25
" Means of handling 52, 66
" Saving by heating feed water 29
" Slack. Value of 27
" Wood. " 27
Furnace. B. & W. smokeless 25
" " " Atlanta award 72
" " " Firing 47
" Efficiency of 25
Heat. Loss of, from steam pipes 45
" Total, of combustion 19, 27
" " of steam 51
" " in water 53
" unit. Value of 53
Heating buildings by steam 35
" feed water. Saving by 29
" liquids by steam 37
Horse power of boilers 21, 59
" " of chimneys 33
" " of different nations 21
" " of steam for drying-rooms 37
" " " for heating buildings 37
" " " for heating liquids 37
" " " through pipes 43
" " Standard 21
Incrustation or scale 9, 13, 31
" Kinds of 31
" Preventing 31

PAGE.

Inspection of boilers. Results of 5
Jacketing for steam pipes. Cheap 45
Loss of heat from steam pipes 45
Melting point of various substances 23
Mineral wool 45
Moisture in steam. Formula for 23, 29, 59
Non-conductors of heat. Table of 45
Orifices. Flow of steam from 43
Petroleum. Apparatus for burning 26
" for incrustation 31
Pipes. Steam. Covering, etc 45
" " Flow of steam through 43
" " Horse power of 43
Priming or wet steam 15, 23, 49, 59
Pumping machinery. Efficiency of 19
Purifying feed water 31
References for Babcock & Wilcox boilers 73, 88
Relative value of non-conductors 45
Requirements for a perfect steam boiler 3
Safety. Attention necessary to secure 47
" in boilers 5, 7, 9, 15, 47
" Water tubes an element of 7
Scale. See "Incrustation."
Separating water from steam 37
Slack for fuel 27
Smoke. Combustion of 13, 25
Smokeless Furnace. Babcock & Wilcox 25
Standard horse power 21
Steam boilers. See "Boiler."
Steam. Boiling by 37
" Drying by 37
" Dry 15, 23, 57, 59
" Economy of 19
" Efficiency of 19
" Engines. Efficiency of 19
" Flow of, from orifices 43
" " through pipes 43
" Heating by 35
" Heat in 55
" per pound of fuel 19, 27, 71
" pipes. Covering 47
" " Flow of steam through 43
" " Loss of heat from 45
" Properties of 51
" Superheated 23
" Volume of 51
" Weight of, per cubic foot 51
" Wet 15, 23, 49, 59
Superheated steam 23
Table of American coals 27
" average results of tests 71
" chimneys 33
" combustibles 27
" conducting powers 27
" flow of steam 43

PAGE.

Table of fusion of metals 23
" horse powers 21
" loss of heat 45
" melting points of metals 23
" mixtures of air and steam 35
" non-conductors 45
" properties of saturated steam 51
" saving by heating feed water 29
" temperature by color 23
" water at different temperatures 53
" woods 27
Tannate of soda 31
Temperature of fire 23
" " to tell by color 23
" " " fusion 23
" of steam 51
Temperatures. Water at different 53
Thermal unit 53
Testing boilers. Formula for 59
Test of boilers at American Inst. Fair 69
" " Arlington Mills 71
" " Benedict & Burnham Mfg. Co 70
" " Brush Elec. Light Co 65, 67, 68
" " Buffalo Grape Sugar Co 70
" " Edison Co. (Menlo Park) 63
" " " (London) 63
" " Genesee Mills 65
" " Greenock Sugar Refinery 61
" " Harrison, Frazier & Co 63, 71
" " Hepburn & Co 71
" " Miami Soap Works 63
" " Mill Creek Distillery 61
" " Oliver Wire Works 61
" " Peacedale Manufacturing Co 65
" " Raritan Woolen Mills 23, 55–59
Tests of boilers. Table of average results of 71
Tubes. Collection of dust in or on 17
" Water *vs.* fire 17
Unequal expansion 5, 7
Value of various combustibles 27
" coverings for steam pipes 45
Water, at different temperatures 53
" Circulation of 5, 15
" Feed, heating 29
" " purifying 31
" Separating from steam 37
Water tubes an element of safety 7
" " self-cleaning of dust 17
Weight of steam per cubic foot 51
" water per cubic foot 53
Wet steam 15, 23, 49, 59
Wood for fuel, value of 27
Wool for covering pipes 45
" Mineral 45

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